QP
No. 2

THE PLANT DISEASE REPORTER

Issued By

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

SUGGESTIONS FOR PREPARATION OF MANUSCRIPTS FOR THE PLANT DISEASE REPORTER

(1) GENERAL: The Reporter page measures 9 inches long with the heading or 8 3/4 inches for the text part, by 6 inches wide. The copy is typed on a larger page, 11 1/4 inches of text or 12 inches overall in length by 8 inches in width, and reduced 25 percent in the photographic process of reproduction. Illustrations or tables larger in either dimension will take a correspondingly greater reduction. Only one size of type is available for text, footnotes, or tables.

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(3) ABSTRACTS are requested for all except very short articles.

(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so.

(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your references carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestion of McCallan et al. in Phytopathology (45 (6): 295-302. 1955).

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

(8) TABLES should be carefully thought out with particular attention to the Reporter's limitations in reproduction. Make titles and headings definite and self-explanatory. Designate footnotes in tables with superscript lower-case letters. Be sure that text discussion agrees with the data in the table. Do not abbreviate names of crop varieties.

(9) REPRINTS cannot be supplied since there is no way in which we can be reimbursed. However,

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ACCEPTANCE OF MANUSCRIPTS

The increase in the volume of pertinent material offered for publication in the Plant Disease Reporter has made it necessary to limit the subject matter and the length of articles accepted. The subject matter should emphasize new things in plant pathology, such as new records of disease occurrence, serious outbreaks and epidemics, conditions affecting development of plant diseases, techniques of investigation including instrumentation, new discoveries in control including new materials and their evaluation. Manuscripts will be limited to 15 double-spaced typed pages. Insofar as possible, material should be presented as graphs rather than tables. Papers cannot be accepted for publication that report routine control experiments, reviews, bibliographies without annotation, results of routine surveys, mere summaries or lists of plant diseases. By following this procedure we hope to continue publishing all articles promptly.

Paul R. Miller

Manuscripts for and correspondence about this publication should be sent to:

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Crops Protection Research Branch
Plant Industry Station
Beltsville, Maryland

THE PLANT DISEASE REPORTER

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THE DEVELOPMENT OF FLORICULTURAL PATHOLOGY IN NORTH AMERICA[1]

Kenneth F. Baker

Summary

Floricultural pathology in North America may be said to have begun with the work of B. D. Halsted at the New Jersey Agricultural Experiment Station from 1890 to 1905. The subsequent development of the subject has been particularly rapid in the last 15 years, as evidenced by both the number and productivity of personnel. Pathologists working on the subject on a full-time basis (part-time staff expressed as a fraction) increased by 1041 percent, from 5.4 in 1925 to 61.6 in 1957, with a total of 91 people actively involved in the latter year. Membership in the American Phytopathological Society increased 166 percent in that period. The increase in number of workers came at about the same times as did membership expansions in the Society, but percentagewise was over 6 times greater. The percentage of the Society membership working on the subject rose from 0.8 in 1925 to 3.5 in 1957, with an average of 2.7 for 1937-1957. The work is presently centered in California, the United States Department of Agriculture, New York, Florida, Oregon, Ohio, the Canadian Department of Agriculture, Washington, Pennsylvania, North Carolina, Louisiana, Illinois, Texas, and Massachusetts, in descending order of number of staff members. Staff size and the importance of the floricultural industry in some States are not proportional.

The number of plant pathology publications showed a steady increase from 4 in 1884 to 628 in 1957 (1131 percent increase over 1911), whereas floricultural pathology papers rose from 1 in 1887 to 35 in 1957 (1650 percent increase over 1912), or about 1.5 times faster. The percentage of all plant pathology papers devoted to floricultural diseases fluctuated between 0 and 10.9 percent from 1905 to 1957, with an average of 6.9 percent for 1937-1957. In 1957 the 3.5 percent of the Society membership who worked on floricultural pathology published 5.6 percent of the papers in Phytopathology. For the period 1925-1957, each Society member published an annual average of 0.26 paper in Phytopathology, whereas floricultural pathologists published 0.66 paper. Probably no more than a fourth of the North American floricultural pathology papers appear in Phytopathology.

Courses in floricultural pathology are taught in at least 13 institutions of higher education in this country.

In this Golden Jubilee year of the American Phytopathological Society it is appropriate to examine the development and present status in North America of some constituent parts of modern plant pathology. Floricultural pathology, one of these parts, has developed rapidly in the last 15 years, and is therefore perhaps not as well understood as those concerned with food and fiber crops.

Floricultural pathology is concerned with the diseases of crops grown in commercial floriculture (cut flowers and foliage; pot, foliage, and bedding plants; cacti and succulents; bulbous crops; herbaceous ornamentals for home gardens; propagative material, seed, and started plants for these crops). Trees, shrubs, landscape materials, and turf are not included.

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[1]Expanded from a paper presented in a session on floricultural pathology at the Stanford University meetings of the American Phytopathological Society, Palo Alto, California, August 25, 1957. The assistance of the many pathologists who supplied data on the questionnaires is gratefully acknowledged.

The industry served by floricultural pathologists has been estimated by the Census of Agriculture as returning $246,577,000 to the growers in this country in 1954 (4). In 1949 there were over 3600 acres of glasshouses, 1160 acres of lath houses, 390 acres of cloth houses, 260 acres of cold frames, plus large areas of open land used in this production (9, p. 26 and 32). There were more than 8000 acres of commercial gladiolus grown in Florida in 1954 (6). There were sold in this country in 1949 more than 38 million chrysanthemum cuttings, 35 million cuttings of foliage plants, 25 million geranium cuttings, 7 million azalea cuttings, and 4 million carnation cuttings (9, p. 33). No later data are available, but there are many indications that a considerable expansion in the industry has since occurred.

Study of the diseases of floricultural plants in North America began, as did that of most other crops, toward the end of the nineteenth century. The more important contributors to the subject prior to 1900 were G. E. Adams, J. C. Arthur, L. H. Bailey, W. C. Blasdale, F. W. Card, P. H. Dorsett, B. T. Galloway, B. D. Halsted, L. F. Kinney, E. F. Smith, F. C. Stewart, G. E. Stone, and A. F. Woods. Halsted, at the New Jersey Agricultural Experiment Station, was particularly prolific, publishing more than 100 notes and papers on floricultural pathology from 1890 to 1905, many of them in trade journals (5). Because of this sustained interest in the subject, he might justifiably be considered as the first floricultural pathologist in America.

Other early contributors were G. F. Atkinson, F. H. Blodgett, W. E. Britton, W. R. Dudley, C. E. Hunn, S. T. Maynard, F. L. Scribner, R. E. Smith, W. C. Sturgis, W. Stuart, R. Thaxter, and W. Trelease. The 25 pathologists named were in the United States Department of Agriculture, Washington, D.C., and the Agricultural Experiment Stations in California, Connecticut, Indiana, Massachusetts, New Jersey, New York (Cornell and Geneva), Rhode Island, and Wisconsin.

Cook (3) in 1916 stated, "While we find a rather extensive literature on diseases of field crops, fruits, and vegetables, we find a very meager literature on the diseases of ornamental plants." He thought this was because most people did not regard ornamentals as economically important, growers had received little help from pathologists and had therefore necessarily learned to live with plant diseases, and pathologists found the study of ornamentals difficult and uncertain. These conditions were probably true at that time, but have now been completely changed. The Census of Agriculture has provided facts on the importance of the floricultural industry. Growers have become organized and are now vigorously seeking assistance on their disease problems. Pathologists have found, once they established cooperative relations with growers, that floricultural disease problems are unusually rewarding subjects of study. Cook further suggested the pathology of ornamentals as a subject suitable for study in urban universities, a shrewd prophecy of modern trends.

The subject had developed sufficiently by 1930 that White (11) pointed out that "Plant pathology as related to ornamental plant materials is the most recent field of the science to be seriously considered." He indicated that its future growth depended on recognition of the increasing value of ornamentals to the public and of the importance of the industry in many States, and the ability of plant pathologists to gain the confidence of growers as well as to convince administrators of the importance of the field. The strengthening of the work since that time has indeed been accompanied by these improvements in intellectual climate.

NUMBER OF PATHOLOGISTS

In order to determine the number of full- and part-time floricultural pathologists in North America for 1925-1957, a questionnaire was sent in the summer of 1957 to a key person in each institution and area where such work was conducted. Data were obtained for the following States and areas: Alabama, Arizona, Arkansas, British Columbia, California (4 places), Colorado, Connecticut, District of Columbia, Florida (4 places), Hawaii, Illinois, Indiana, Louisiana, Maryland, Massachusetts (2 places), Michigan (2 places), Minnesota, Missouri, New Jersey, New York (4 places), North Carolina, Ohio (3 places), Ontario (2 places), Oregon, Pennsylvania, Texas (2 places), Washington (2 places), and Wisconsin (2 places). Several other areas reported that no work was being done in this field. It is thought that a reasonably accurate record of the number of the floricultural pathologists was obtained for recent years, with somewhat less reliable data for the twenties and thirties. Research, extension, and teaching were included. The number of full-time workers was recorded. The sum of the fractions of time spent by part-time workers was expressed as a full-time equivalent (F. T. E.). For the years 1950-1957 the actual numbers of part-time workers were also tabulated. These data are presented in Figures 1 and 2.

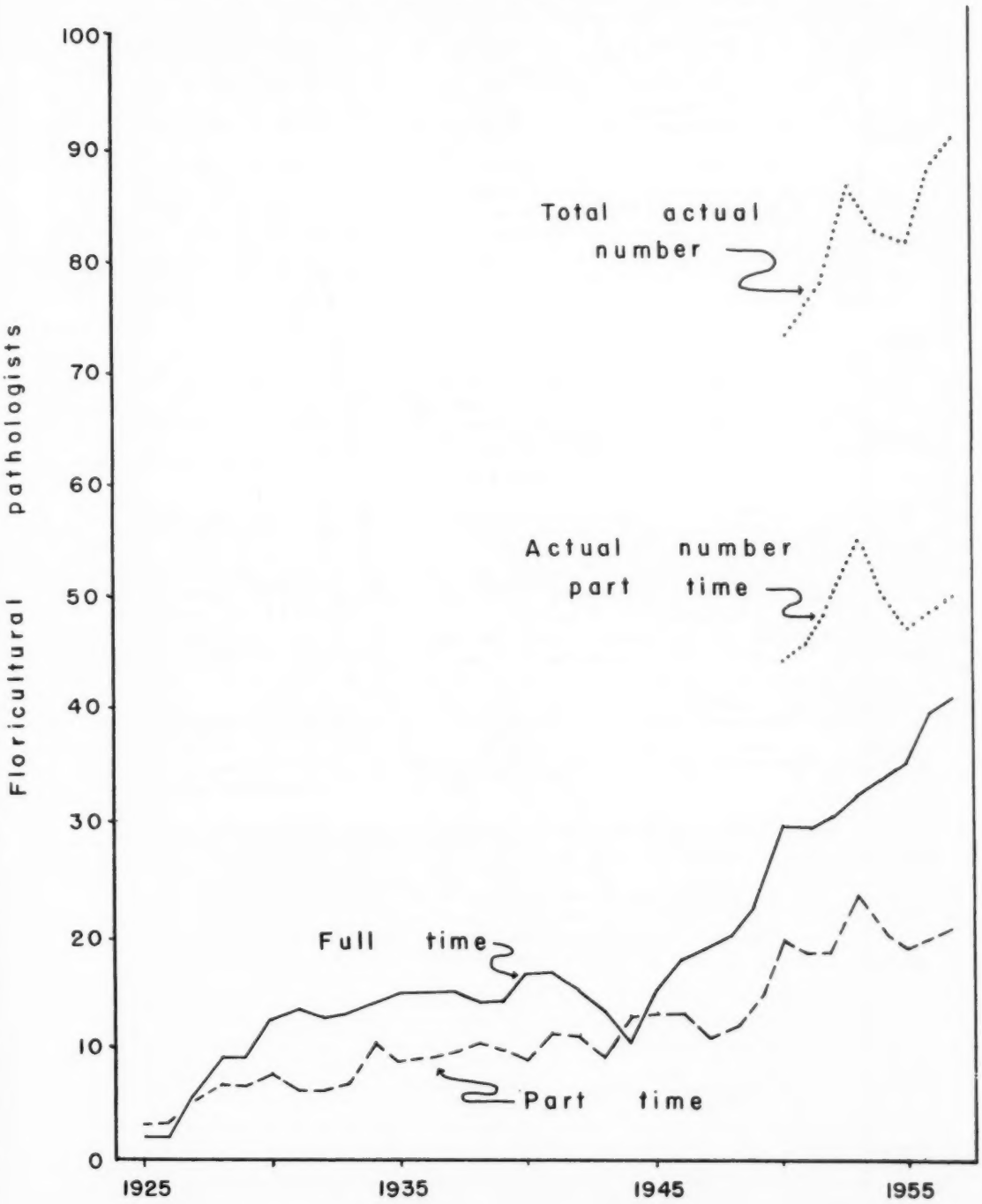

FIGURE 1. The number of floricultural pathologists in North America, 1925-1957. Part-time workers, 1925-1957, are given on a full-time-equivalent basis (F. T. E.) in the bottom graph, and in the upper graphs as the actual number who worked part time, 1950-1957. The total actual number, 1950-1957, is the number of full-time workers plus the actual number of part-time workers.

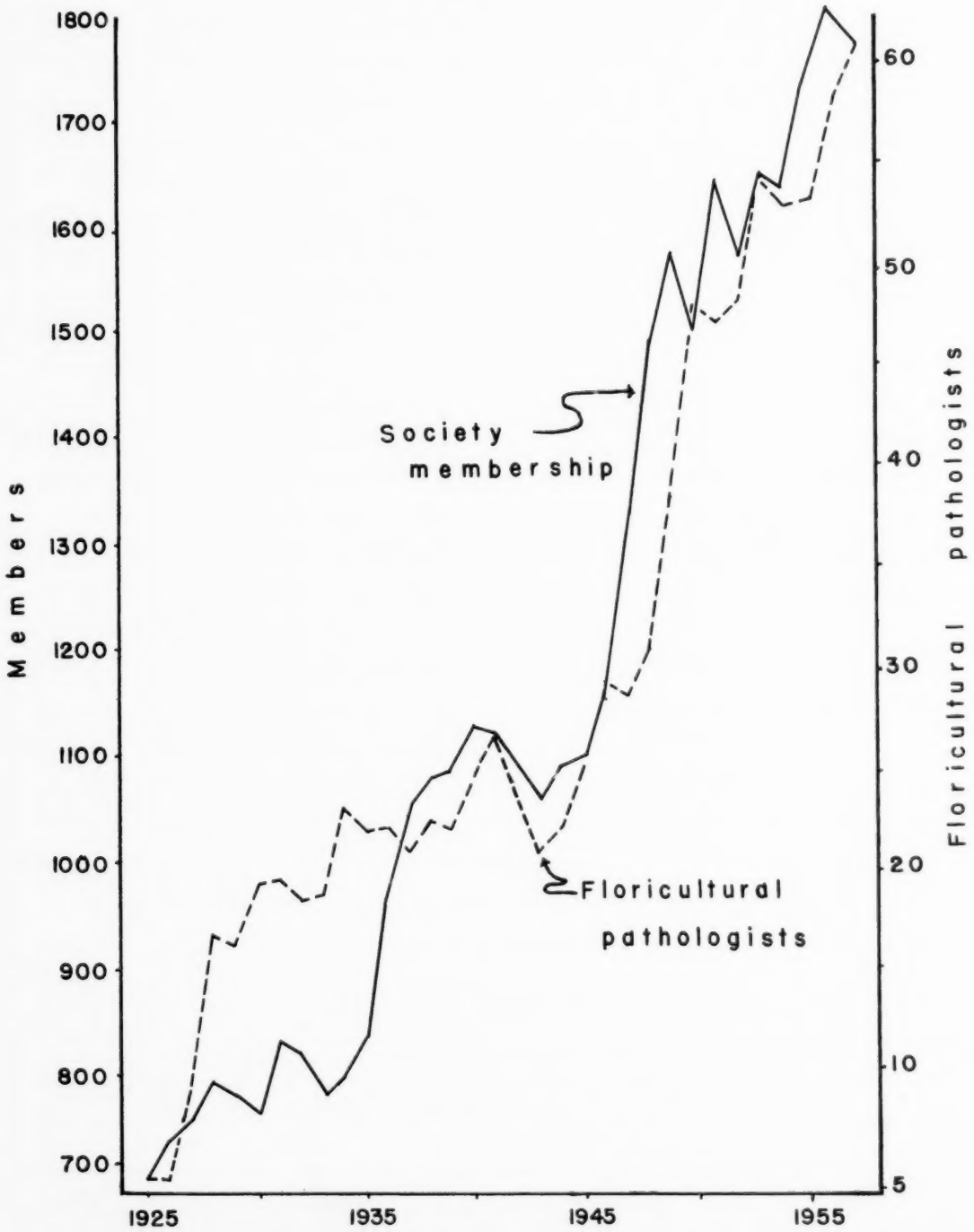

FIGURE 2. The membership of the American Phytopathological Society, and the number of floricultural pathologists in North America, 1925-1957. The number of members is exclusive of Sustaining Members. Floricultural pathologists include full-time workers plus the full-time equivalent (F. T. E.) of part-time workers in that field.

Time of Increase -- There was an increase from 1925 to 1957 in the number of full-time floricultural pathologists from 2 to 41, of part-time (F. T. E.) from 3.4 to 20.6, and of the total (F. T. E.) from 5.4 to 61.6 (Fig. 1). The fact that the number of part-time workers (F. T. E.) rose only slowly during this period, whereas full-time rose rapidly after 1944, indicates that most of the new appointments in the last 13 years have been on a full-time basis. The actual total number who worked on floricultural pathology increased from 73 in 1950 to 91 in 1957 (Fig. 1).

The membership of the American Phytopathological Society for 1925-1957, exclusive of Sustaining Members, was obtained from the Annual Reports of the Secretary, published in Phytopathology. These numbers, and the total number of floricultural pathologists (F. T. E.), are shown in Figure 2, graphed to show their comparative increase in time. It is apparent that the two groups generally increased at the same times during this period. The rate of increase fell off in each case during the depression 1930's and during World War II. The number of floricultural pathologists increased from 1926 to 1934, but steadily and very rapidly from 1944 to 1957.

Rate of Increase -- The rate of increase over 1925 is shown in Figure 3 for the members of the Society and the number of floricultural pathologists (F. T. E.) in North America. The membership increased 166 percent in this interval, whereas the number of floricultural pathologists increased 1041 percent. The percentage increase of floricultural pathologists was 6.3 times as much as the membership in this period. The effects of the depression and World War II were again apparent.

Percentage of Members Working on Floricultural Pathology -- From the above data were calculated the percentage of the membership of the Society who worked (F. T. E. basis) on floricultural pathology in 1925-1957 (Fig. 4). This increased from 0.8 percent in 1925 to 3.5 in 1957, with an average of 2.7 percent for 1937-1957. The actual total number who worked in the subject ranged from 4.9 percent of the Society membership in 1950 to 5.1 percent in 1957. Using data derived from directory cards returned by 1310 members of the Society in 1952, McCallan (7) found that 75, or 5.7 percent, listed ornamentals as a field of interest. By comparison, ahead of ornamentals were the 15.6 percent who listed fungicides, 13.2 who listed pathology of vegetables, 10.2 cereal pathology, 9.0 virology, 8.9 plant breeding and disease resistance, 8.3 forest and shade tree pathology, 7.8 fruit pathology, 6.9 mycology, and the 6.5 who listed fungus physiology. Floricultural pathologists were tenth among all interest-groups, and fifth among crop-pathology groups. The agreement between the 4.9 percent floricultural pathologists in 1952 obtained in this survey, and the 5.7 percent obtained by McCallan is surprisingly good.

Locations of Floricultural Pathology Work -- An active program in floricultural pathology is now being conducted in about half the States in this country, as well as in the Hawaiian Islands. Work is also conducted in two Provinces of Canada.

The United States Department of Agriculture has had a large group in this field for the longest period, averaging 4.6 full-time and 1.5 part-time workers during the 30 years, 1928-1957. Approximately half of these workers have been in Beltsville-Washington, D. C., and half stationed in Oregon, New York, Georgia (for a time in Louisiana and Alabama), and Arizona (Table 1).

The oldest center of floricultural pathology work in this country apparently was the New Jersey Agricultural Experiment Station about 1890, but this lead was maintained for only about 15 years. Maryland, New York, and Ohio, as well as Canada, have had at least a half-time worker more or less continuously since 1925.

The average number of floricultural pathologists in various areas in the past 10 years is shown in Table 1. California, which has conducted such studies for only about 25 years and appointed its first full-time floricultural pathologist in 1939, has been first in available manpower during the past 10 years. It has been followed by New York, Florida, Oregon, Ohio, Washington, Pennsylvania, North Carolina, Louisiana, Illinois, Texas, and Massachusetts.

In some States, there are discrepancies between the number of floricultural pathologists and the relative importance of the floricultural industry (Table 1). Since the floricultural pathology manpower situation has improved so markedly for the country as a whole in the last decade and a half, it is hopeful that a better balance between staff and industry importance may be reached in States presently having limited personnel. It should be noted that the discrepancy for a number of States not listed is at least as great as for those tabulated.

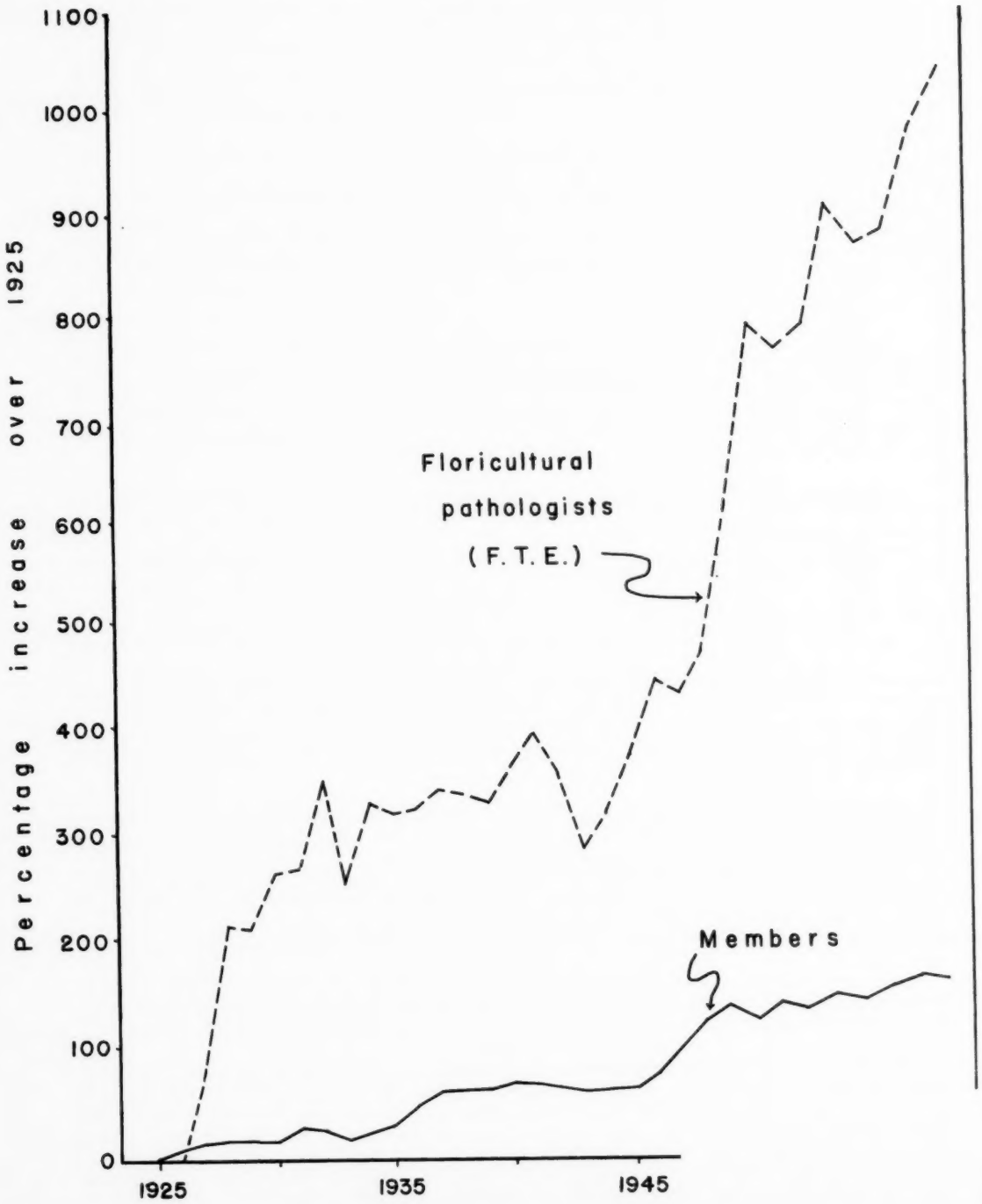

FIGURE 3. The percentage increase over that in 1925 of the number of members of the American Phytopathological Society and the number of floricultural pathologists in North America. Membership counts are exclusive of Sustaining Members. Floricultural pathologists include full-time and part-time workers on a full-time-equivalent basis.

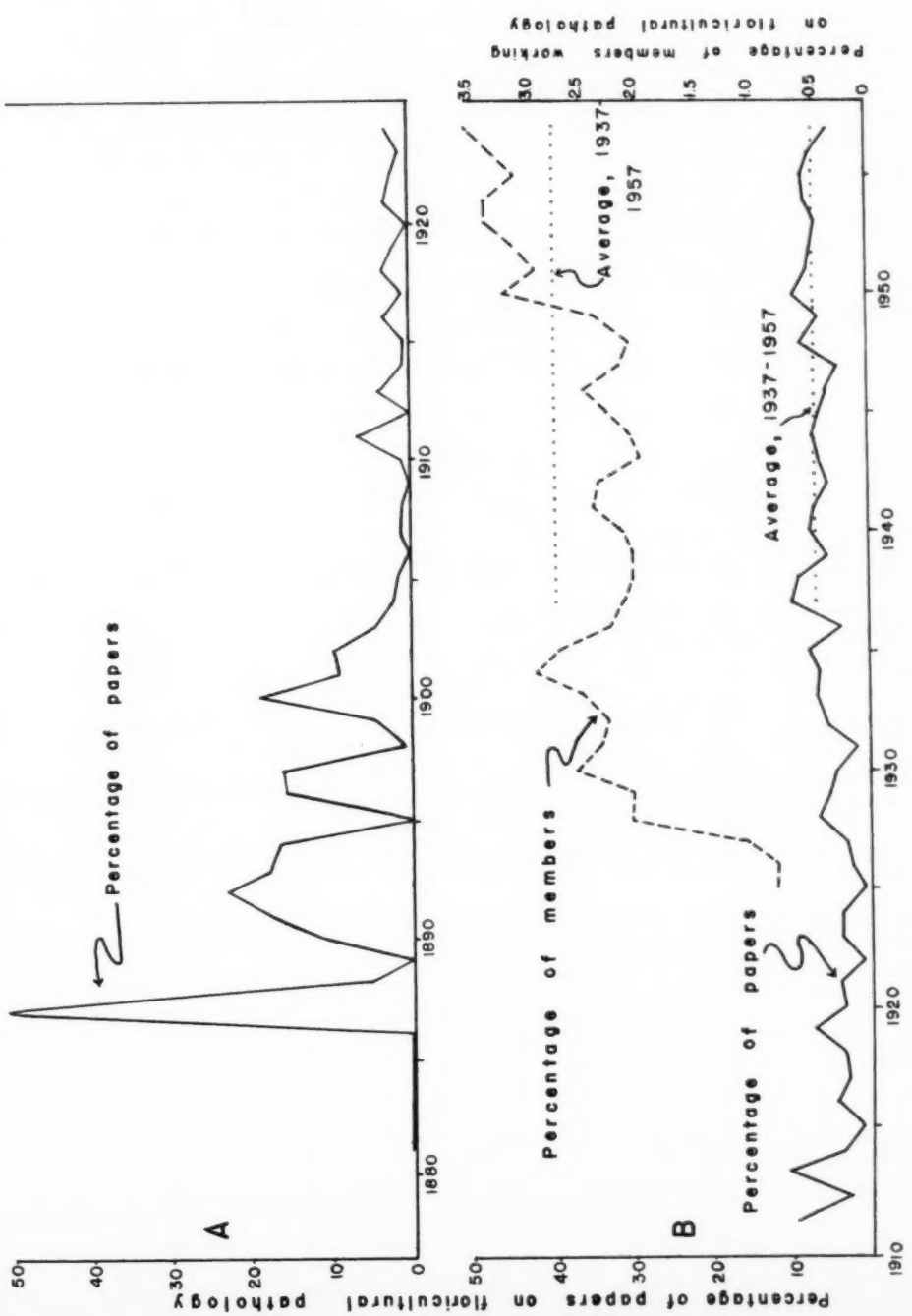

FIGURE 4. The percentage of the total plant pathology papers concerned with floricultural pathology in North America, 1881-1957, and the percentage of members of the American Phytopathological Society working on floricultural pathology full- and part-time (F. T. E.), 1925-1957. The average for 1937-1957 is shown for each. A -- Data for 1881-1924, based on bibliographies (1, 2) of State Experiment Stations and the U. S. Department of Agriculture. B -- Data for 1911-1957 based on papers published in Phytopathology.

Table 1. Average number of full- and part-time (F. T. E.) floricultural pathologists in the 22 leading areas of North America in the 10-year period, 1948-1957, compared with the relative importance of the industry.

Geographical area, and number of localities represented	Floricultural pathologists				
	Full-time	Part-time	Total	Ranking among States	Ranking of floricultural industry[a]
California (3)	5.5	2.7	8.2	1	2
University of California, Los Angeles (1)	4.5	1.6	6.1	--	--
U. S. Department of Agriculture (5)	5.1	1.8	6.9	--	--
Beltsville, Maryland (1)	3.2	0.3	3.5	--	--
New York (3)	4.5	0.1	4.6	2	3
Florida (4)	3.2	0.9	4.1	3	6
Oregon (1)	2.0	1.6	3.6	4	17
Ohio (2)	2.6	0.3	2.9	5	4
Canadian Department of Agriculture (3)	1.5	1.0	2.5	--	--
Washington (2)	2.0	0.2	2.2	6	15
Pennsylvania (1)	0.2	1.4	1.6	7	1
North Carolina (1)	1.1	0.5	1.6	8	21
Louisiana (1)	0	1.4	1.4	9	41
Illinois (1)	1.0	0.2	1.2	10	5
Texas (2)	1.0	0.1	1.1	11	20
Massachusetts (1)	0.8	0.2	1.0	12	8
Hawaii (1)	0.2	0.8	1.0	--	--
Michigan (1)	0.4	0.5	0.9	13	10
New Jersey (1)	0	0.8	0.8	14	7
Colorado (1)	0	0.8	0.8	15	11
Wisconsin (2)	0	0.8	0.8	16	14
Maryland (1)	0.2	0.5	0.7	17	18
Minnesota (1)	0	0.5	0.5	18	16
Connecticut (1)	0	0.5	0.5	19	12

[a]Based on the U. S. Census of Agriculture for 1949 (9, p. 40-41), value of cut flowers and flowering plants at wholesale prices.

PUBLICATION PRODUCTIVITY OF PATHOLOGISTS

Two different samples were taken of the publication record of North American plant pathologists. While both series are admittedly incomplete, they supply an indication of trends. The period, 1881-1924, was covered by two Bibliographical Contributions of the United States Department of Agriculture Library (1, 2). The total listed number of papers by pathologists of the United States Department of Agriculture and the State Agricultural Experiment Stations in official publications and the Journal of Agricultural Research in each year were counted, eliminating duplications. The papers prior to 1881 were too few (22 in 35 years) to be considered. The papers primarily on floricultural pathology were likewise tabulated by year. Because of the incomplete listing of papers of the Annual Reports of the New Jersey Agricultural Experiment Station in Bibliographical Contribution 16, the originals for 1887-1905 were consulted, and the number of plant pathology papers and those concerned with floricultural pathology (minus any duplications) were added to the totals for the respective years.

The period, 1911-1957, was covered by the journal Phytopathology, abstracts, papers, and notes being tallied for each year. Omitted in the counts were abstracts by title only, book reviews, obituaries, and personal and society news items. In a number of cases abstracts of papers presented before the national or a division meeting in 2 different years have been published in a single volume. To more fairly present the true publication trend in such cases, each meeting was moved to its proper year so that no doubling occurred; this affected the data for 1914, 1915, 1920-1925, and 1952-1955, inclusive. The number of papers primarily on floricultural pathology were also tabulated for each year on the same basis.

Time of Increase -- The comparative total number of papers and those concerned with floricultural pathology for the 77-year period, 1881-1957, are shown in Figure 5. The total number of papers showed a steady rise from 1883 to 1957, with slight declines following World Wars I and II, and the depression of the 1930's. It is to be expected that the decline in publications would occur somewhat more tardily than the decrease in number of members. The total number of papers also is more variable from year to year than is the membership.

The number of papers in floricultural pathology followed the general trend of the total papers, with some deviations as explained under Rate of Increase below. The total number of papers increased from 4 in 1884 to 51 or 61 in 1911 (depending which set of data is used), to 153 or 209 in 1924, to 628 in 1957. The floricultural pathology papers increased from 1 in 1887 to 4 or 5 in 1911, to 4 or 8 in 1924, to 35 in 1957. There have been 711 papers on the subject published in Phytopathology alone since 1911.

Rate of Increase -- The rate of increase of publications in plant pathology is shown in Figure 6, with the 51 Phytopathology papers in 1911 taken as a base. The total papers increased from 0 percent in 1884 to 0 or 20 percent in 1911 (depending on which set of data is used) to 310 or 200 percent in 1924, to 1131 percent in 1957. The rate of increase of papers on floricultural pathology is also shown in Figure 6, with the two Phytopathology papers in 1912 taken as a base. The floricultural pathology papers ranged from 0 percent in 1884 to 800 percent in 1892, to 0 in 1912, to 300 or 100 percent in 1924 (depending on which set of data is used), to 1650 percent in 1957.

The number of floricultural pathology papers increased 1.5 times faster than did the total papers in the period, 1912-1957. The trend in the number of floricultural pathology papers generally followed that of all pathological papers (Figs. 5 and 6). They increased more rapidly than the total in 1890-1902 (except for 1895 and 1898-1899), largely due to Halsted's papers. They lagged behind the total from 1904 to 1927 (except for 1911, 1913, 1916, and 1919). From 1928 to 1957 (except for 1931 and 1936), they increased more rapidly than did the total. The effect of World War I and the depression 1930's was not clearly apparent in the numbers of either type of paper, but World War II produced a noticeable decrease.

Percentage of Papers Concerned with Floricultural Pathology -- The percentage of the plant pathology papers published in North America in 1881-1957 which were concerned with floricultural pathology are shown in Figure 4. The period of Halsted's productivity, mentioned before, is evident from 1890 to 1905. The percentage fluctuated from 0 to 10.9 thereafter. In the period, 1937-1957, the average was 6.9 percent.

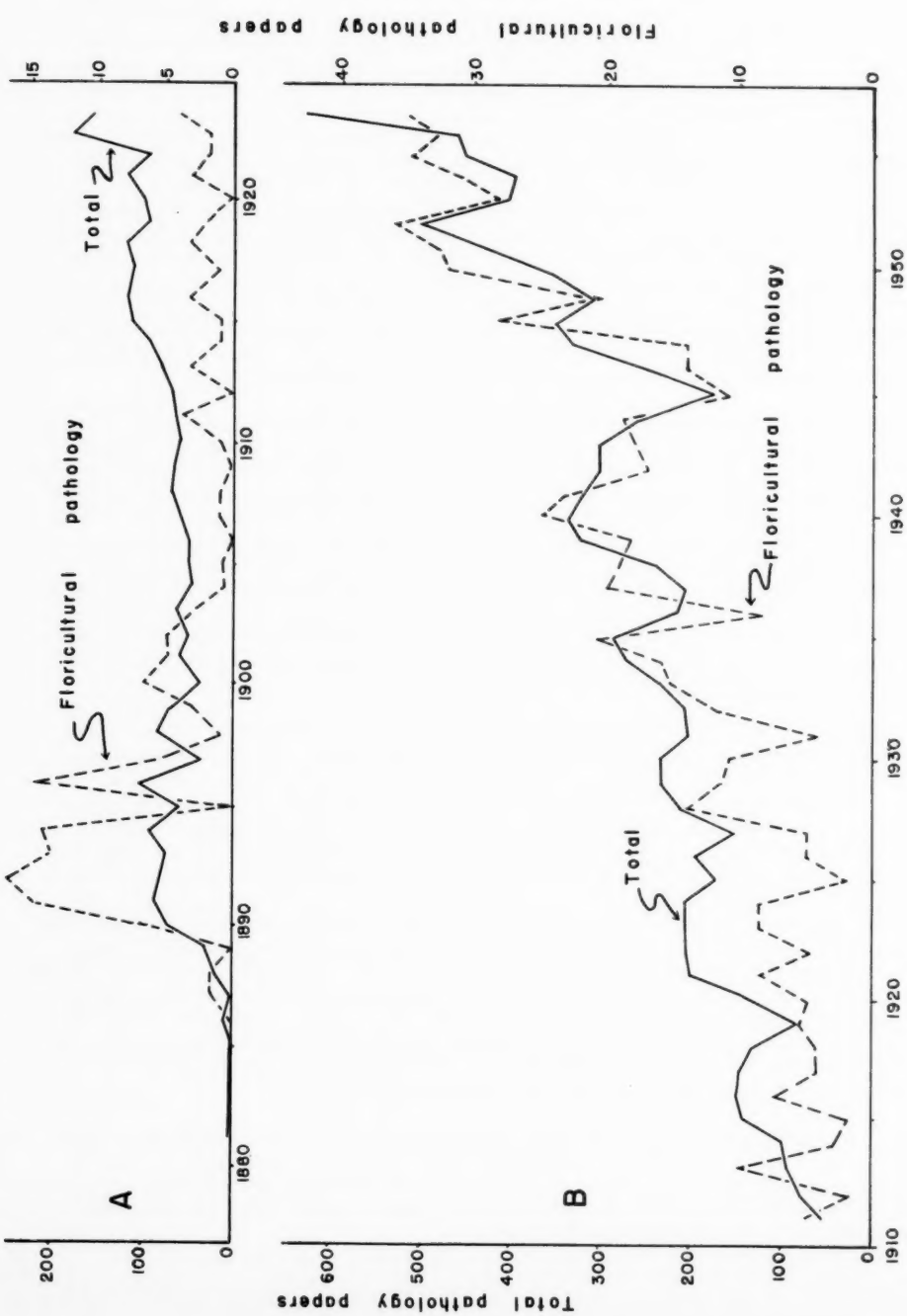

FIGURE 5. The comparative number of papers in plant pathology and in floricultural pathology in North America, 1881-1957. A -- Data for 1881-1924, based on bibliographies (1, 2) of State Experiment Stations and the U. S. Department of Agriculture. B -- Data for 1911-1957 based on papers published in Phytopathology.

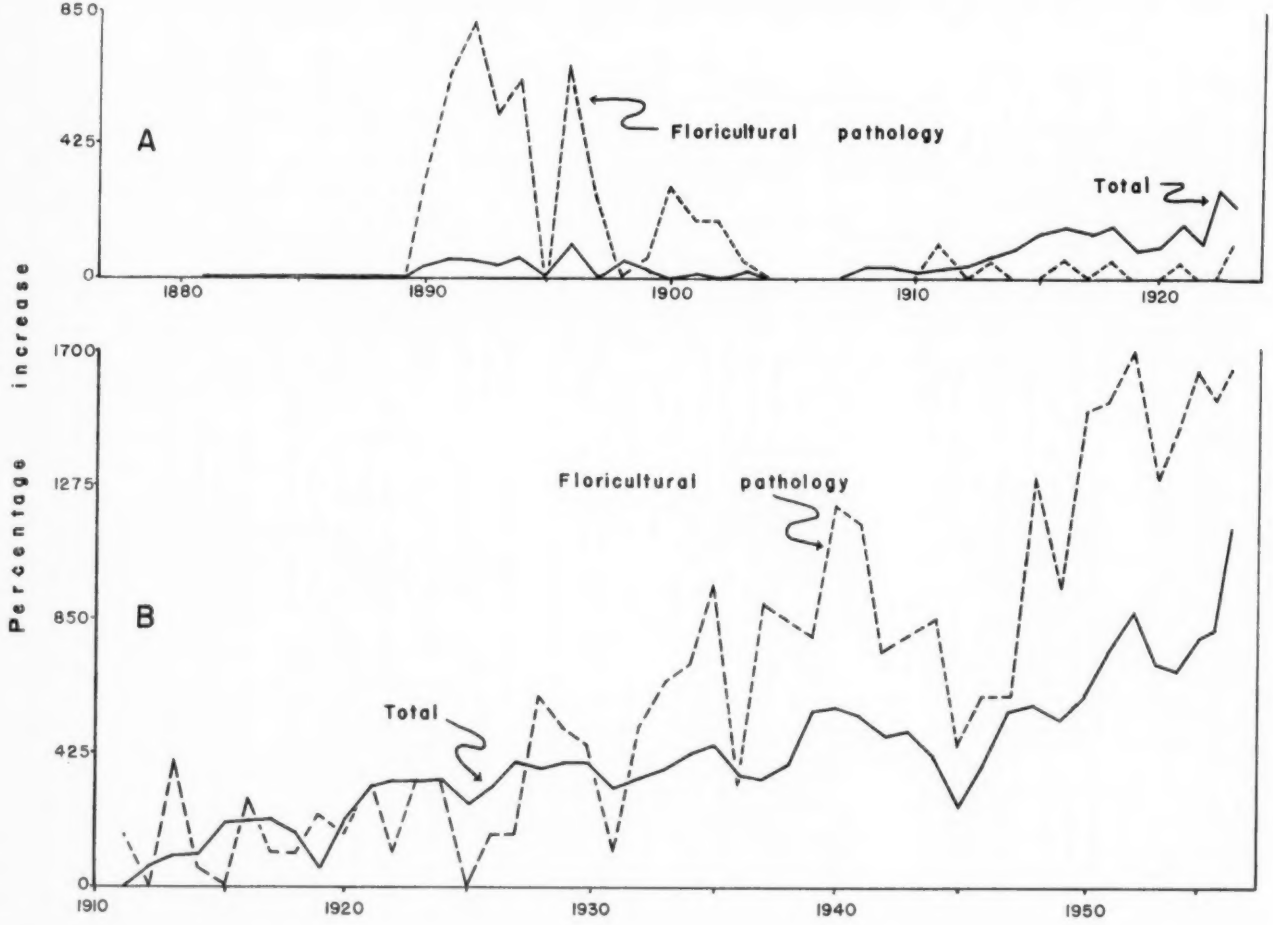

FIGURE 6. The rate of increase in publication of papers in plant pathology and in floricultural pathology in North America, 1881-1957. The total papers published in Phytopathology in 1911 (B) is taken as the base for the total number of papers, and the floricultural pathology papers in Phytopathology in 1912 (B) is taken as the base for floricultural pathology papers in both graphs. A -- Data for 1881-1924, based on bibliographies (1, 2) of State Experiment Stations and the U. S. Department of Agriculture. B -- Data for 1911-1957 based on papers published in Phytopathology.

Papers Published Per Pathologist -- From the preceding data were computed the average annual number of plant pathological publications per member of the Society and of floricultural pathological papers per floricultural pathologist (Fig. 7). These data were quite variable from year to year, and this was more pronounced for floricultural pathologists than for all members, probably because of the smaller number involved. The effect of the depression in the 1930's and of World War II was evident. The average for 1925-1957 for the entire membership was 0.26 per year, and for the floricultural pathologists was 0.66.

There was no detectable increase in productivity per member for the period, 1925-1957. Price (8) also noted that, although the Society membership increased 138 percent from 1925 to 1954, the papers published in Phytopathology increased only 59 percent. He queried: 1) is interest in the field increasing faster than the output of research; 2) is Phytopathology attracting a smaller proportion of member's output in 1954 than in 1924; 3) is it now more difficult to make a contribution than it used to be?

The data presented here indicate that floricultural pathologists, comprising 3.5 percent of the Society membership in 1957, produced 5.6 percent of the papers in Phytopathology. Has this resulted from the fact that floricultural pathology has developed relatively recently, thus yields publishable material more easily, and is more stimulating to workers than the much-studied diseases of other crops? Is it perhaps because the intensive culture, largely controlled environment, annual nature, and high unit value of many of these crops present greater possibilities for disease control, and therefore for faster publication? Do floricultural pathologists tend to publish a higher percentage of their papers in Phytopathology than do other workers?

Place of Publication of Papers -- There have been, during the period since 1890, a number of trade journals which published semi-technical and popular papers on diseases of floricultural crops. Halsted published a great many papers in such journals at the close of the century. There have also been an increasing number of Journals, Annuals, and Yearbooks published by Societies, each specializing in one crop or group of related plants. Commercial companies have begun publishing journals which are widely distributed. State Agricultural Experiment Stations have started publishing magazines presenting the results of their research. In several States, the Agricultural Extension Service, at both the State and County levels, is publishing the results of research. State Florists' Associations, apparently beginning in Ohio in 1929, also have published magazines reporting new research. At the present time there are more than 75 such publications in North America which contain papers on floricultural pathology. This situation makes difficult the task of keeping abreast of new developments in the field, because experimental results often appear first in these restricted publications, and all too frequently appear nowhere else.

In order to determine what portion of their papers floricultural pathologists are publishing in journals other than Phytopathology, a sample count was run for the year 1957 on 23 "trade journals" of the types mentioned above. This necessarily sketchy survey showed that 60 papers on floricultural pathology were published there, as against 35 in Phytopathology in 1957. This tabulation did not include numerous professional journals in which floricultural pathology papers are also published. Probably no more than a fourth of the North American floricultural pathology papers appear in Phytopathology. It is concluded that the data compiled from Phytopathology afford a very conservative estimate of the number of papers on that subject. Indeed, it is probable that a lower percentage of the papers by floricultural pathologists are published in Phytopathology than is the case with other crop pathologists.

Quality of Published Papers -- In a book review (10) in 1944, the statement was made that in pathology of ornamentals "...standards of thoroughness and accuracy to be expected in ... the pathology of economic crops cannot yet be demanded here." It is true that no diseases of floricultural crops have been studied as thoroughly as stem rust of wheat, apple scab, or stinking smut of wheat, but neither have many other important plant diseases. Probably the important diseases of the 20 major floricultural crops are as well understood as those of comparable vegetable, fruit, or cereal crops. However, this may not be apparent to one not working in the subject, because (a) much of the literature is scattered in sources not generally seen by non-specialists, and (b) the large number of plants (over 250 genera) grown by the floriculture industry inevitably means that the information is fragmentary about the diseases of a number of them.

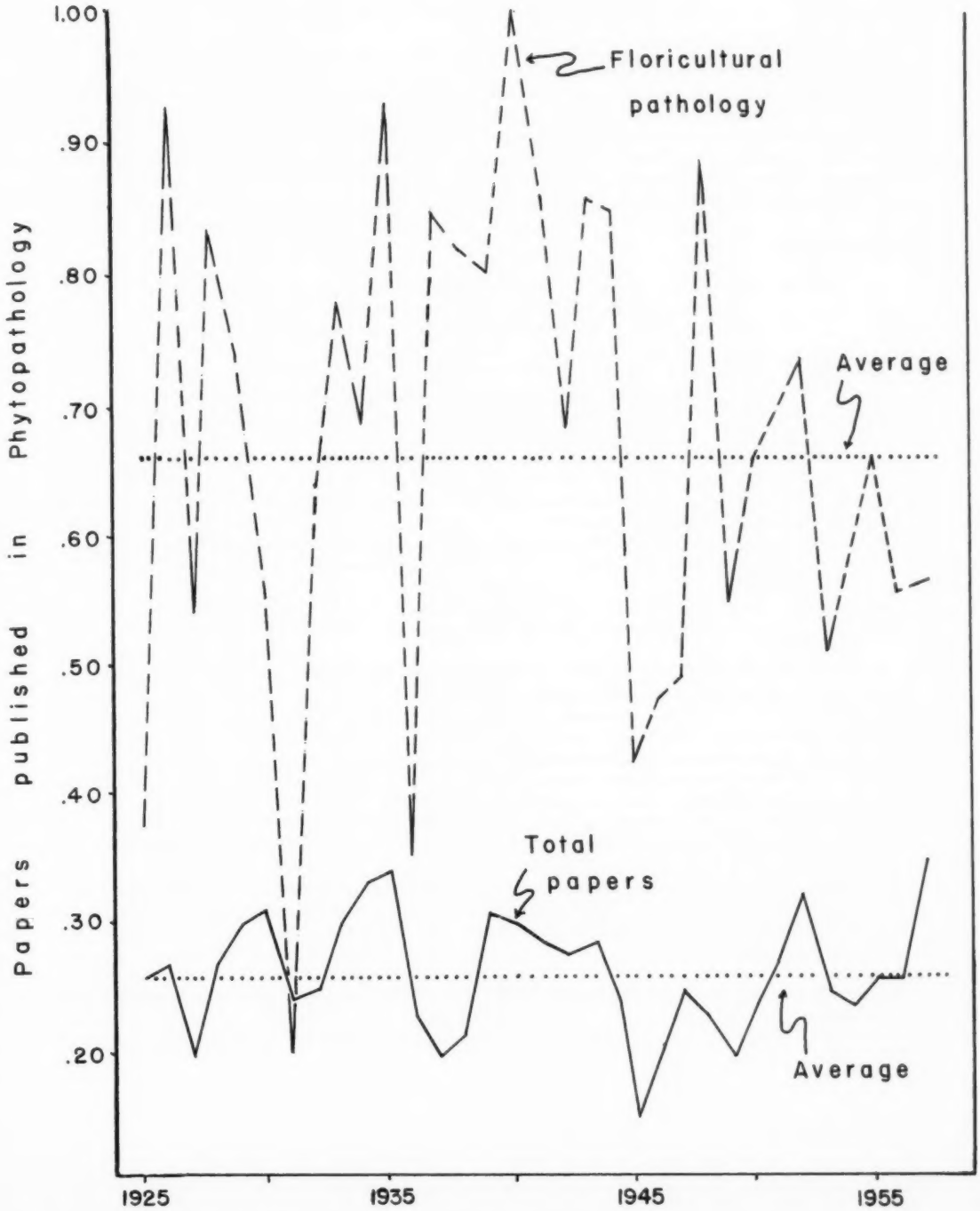

FIGURE 7. The number of papers published annually in Phytopathology by each member and by each floricultural pathologist, 1925-1957. The average for the period is shown for each.

TEACHING OF FLORICULTURAL PATHOLOGY

Courses in floricultural pathology are taught, or have been in the recent past, in the following institutions in this country, based on the survey returns: University of Arizona; University of California, Los Angeles; California State Polytechnic College, Kellogg-Voorhies and San Luis Obispo campuses; Colorado State University; Florida State University; University of Maryland; Michigan State University; University of Missouri; Oregon State College; Pennsylvania State University; Rutgers University; Texas A. and M. College; Washington State College. Since there may be a number of institutions not contacted in this survey which also offer such courses, this list cannot pretend to completeness.

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THE DRY ROT DISEASE OF GLADIOLUS[1]

Charles J. Gould[2]

INTRODUCTION

This is a summary of recent information on the dry rot disease of gladiolus (Stromatinia gladioli (Drayton) Whetzel). It has a two-fold purpose: (A) to make available to others the fruits of a literature review prepared originally for use at a gladiolus disease research conference sponsored by the North American Commercial Gladiolus Growers Council at Pittsburgh, Pa., January 22, 1957, and (B) to present hitherto unpublished data from certain experiments at the Western Washington Experiment Station, particularly those on soil treatment. The information is grouped as follows.

THE DISEASE
THE PATHOGEN
FACTORS AFFECTING INFECTION
CORM TREATMENT
SOIL TREATMENT

In general, the available information raises more questions than it supplies answers. As will be noted, the effects of such factors as moisture and temperature on fungus attack and disease development need additional and very critical investigation.

Symptoms and history of dry rot and description of the causal organism were adequately covered by Moore up to 1939 (53). In recent years Magie (36, 37) and Gould (30) have published popular descriptions of the disease. Therefore, this article will be confined primarily to technical aspects and to publications after 1939. The most important technical articles have been by Massey (52), Drayton (20, 21) and Hawker et al. (33).

THE DISEASE

Description

Infection of young plants results in stunting, yellowing, and eventual death, singly or in clumps (Fig. 1). Larger plants are not killed as readily, but the bases of stems and leaves are rotted with a brown to black color. A gray-white mold may develop between the infected leaf sheaths. The outer leaf bases are usually shredded (Fig. 2) and more or less covered with very small black sclerotia of the pathogen. Sclerotia also occur, but less frequently, on lesions on husks, corms and roots.

Lesions on corms are at first very small and reddish brown, later becoming larger with a dry, shallow, dark brown to black rot (Fig. 3). The spots often fuse, particularly at the nodes, producing a ring-like appearance. The rot often extends inwards along the vascular strands and, under favorable conditions, converts the corm into a hard, black, dry mummy. Infected husks are usually discolored, brittle, and shredded. Roots may rot and the outer portion slough off. Young corms are supposed to be more susceptible than old ones and become less susceptible as the growing season advances (33). Diseased corms do not always give rise to infected daughter corms. The percentage varies according to soil conditions (33).

Not all symptoms are necessarily present at one time nor in one area. The type of attack apparently depends upon a certain combination of various climatic and soil factors. Thus, in western Washington most losses occur from corn and stem rots, whereas in Florida (40) over 90 percent of the damage is caused by root rotting, with neck rotting being next in importance.

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[1]Scientific Paper No. 1713, Washington Agricultural Experiment Stations. Work was conducted under Project No. 422.

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FIGURE 1. Clump of stunted and dying gladiolus plants affected with dry rot.

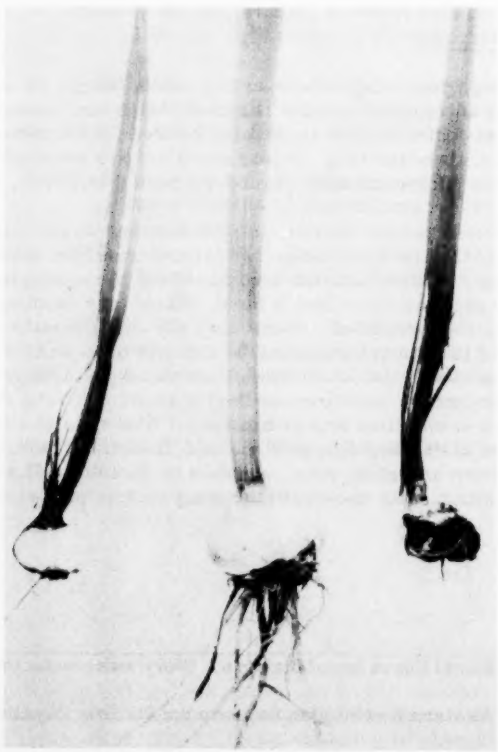
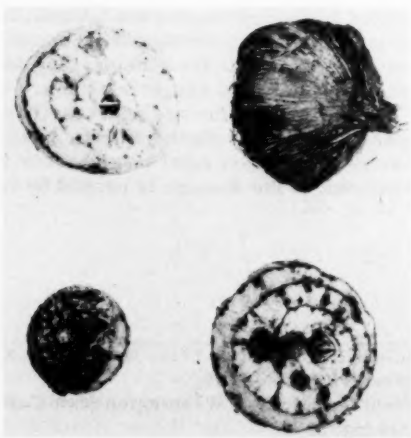


FIGURE 2. Shredding of stems of diseased plants (left and right) compared with healthy (center).

FIGURE 3. Dry rot symptoms on corms.



Distribution

Moore (53) summarized reports of dry rot on gladiolus in the United States, Holland, England, France, Denmark, Germany, Scotland, and Canada. The disease has since been reported from enough other countries (e.g. Australia (1, 2, 26), Bulgaria (18), and Japan (8)) to indicate that it is probably world-wide in distribution. Weiss and O'Brien (70) reported Stromatinia as being generally distributed in the United States on gladiolus.

The other hosts in Weiss and O'Brien's check list (70) include Crocus (from New Jersey, New York, Washington, and on imported stock); Freesia (New Jersey and New York) and Tritonia (general). Moore (53) lists these plus Galanthus, Acidanthera, and Lapeirousia. Sakaguchi (66) described a disease of narcissus caused by S. gladioli and stated that he had reproduced the disease in 12 varieties of narcissus, and in tulip, onion, and gladiolus by artificial inoculation. He also reported the presence of the fungus on tulip bulbs imported from Holland. Drayton (20), however, did not observe any infection in several varieties of rhizomatous iris, tulip, hyacinth, or narcissus planted in dry-rot-infested soil.

Thus, the fungus definitely appears to be world-wide in distribution and may have a rather wide host range, with perhaps three families (Iridaceae, Liliaceae, and Amaryllidaceae) represented by ten genera.

Importance

Nelson (54) and Magie (37) have called dry rot one of the major corm-borne diseases of gladiolus. Based upon reports at the 1953 Cleveland Gladiolus Disease Conference, Ryan (58) stated that the importance of dry rot varies with the climate and that it is "most serious in Michigan, western Washington, northern Oregon, northern New Jersey and Wisconsin; and not too serious in Illinois or Indiana. It is seasonal in California, New York, Florida and North Carolina". Ryan and Ulman (65) said that dry rot was more severe in 1954 than usual. Young and Palm (74) have reported it as being of major importance in the Willamette Valley of Oregon, and Gould has stated (30) that it was responsible for most losses from corm rot in western Washington. Baker (11) mentioned dry rot as one reason why gladiolus plantings have been moved continually in California. Subsequently, Bald (13) stated that the disease had eliminated the culture of gladiolus from certain fields, and in another report (12) said it was becoming increasingly serious in California. Haasis (32) reported that dry rot had been frequently observed in North Carolina and that in some instances the losses were considerable. A report from Holland (6) mentioned that dry rot is a disease that appears regularly in gladiolus and gives much cause for alarm. Another Dutch report (7) stated that the spread is rapid and that lots could be 100 percent infected by July 1. Magie (40) reported in 1956 that over 1000 acres of the better frost-protected lands on Florida's west coast were so infested with the dry rot that winter crops of gladiolus could not be grown profitably. Some Florida growers on the Gulf Coast consider it their most important production problem (45). Magie (36) reported that in 1953-54 dry rot caused an estimated loss of over $100,000 in the Tampa Bay area alone. This is the only specific figure given by any author, but there can be no doubt but what dry rot is general and serious. The disease is apparently more serious in the Pacific Northwest than elsewhere in average years.

THE PATHOGEN

The fungus has been, and still is, referred to by the following different scientific names: Sclerotium gladioli Massey; Sclerotinia gladioli (Massey) Drayton; and Stromatinia gladioli (Drayton) Whetzel. The latter name (71) is generally used now by most pathologists in North America. There has been some question about the exact status of the genus Stromatinia. Drayton and Groves (22) have recently presented arguments supporting its validity as a genus.

Sclerotia

In 1954 Magie (36, 37) reported finding sclerotia on diseased roots. A year later a Dutch report (7) also mentioned a similar discovery. Townsend and Willetts (69) have described the formation of sclerotia by a coalescing of mycelial branches. Magie (47) believes that sclerotia are conditioned by warm weather but that the germination of sclerotia is triggered by cool weather, after which the actual germination may occur at higher temperatures. His observations (47) indicate that the sclerotia that are capable of germinating do so in Florida early in

the fall. Following germination, the active mycelium gradually dies out. As a result, plantings made after January 1 are generally healthy.

Fundamental research into specific conditions affecting sclerotium formation and activity is definitely needed.

FACTORS AFFECTING INFECTION

Longevity

It is well known that the fungus survives in soil for a considerable time. Hawker et al. (33) stated that planting in infested soil could result in 100 percent infection, depending upon soil type and other conditions. A Dutch report (7) indicates that the fungus may have survived 15 years in the absence of gladiolus in that country. Nelson (54) reported an instance of the fungus remaining in the soil for 10 years in the absence of gladiolus. Massey (52) stated that it could survive for at least 5 years. The fungus may survive for long periods in Florida (47). Growers in western Washington have stated that, once established, dry rot can survive almost indefinitely. Gould (reported by Ryan, 60) found that it can persist for at least 2 years in the absence of the host, in light and medium sandy loams, silt and peat soils. Yamamoto et al. (73) stated that the fungus grows readily in garden soil mixed with rice, wheat or barley bran, but not in garden soil alone. Yamamoto (72) also reported that various strains of Trichoderma destroyed most of the mycelium of S. gladioli within 7 days after inoculation of the latter.

Temperature

Massey (52) reported that the minimum, optimum and maximum temperatures for growth of the fungus in culture are about 32°, 77°, and 95° F respectively. Hawker et al. (33) and Nelson (54) stated that warm temperatures increase losses, but this may be primarily a matter of acceleration of symptom expression. Generally, most severe attacks outdoors seem to occur under relatively cool conditions. Thus, Gould (30) reported planting samples of corms from a dry-rot-infested stock in both eastern and western Washington in 1947. Average temperatures for July and September were about 72° and 61° for eastern Washington vs. 64° and 59° for western Washington. In spite of the warmer temperatures in eastern Washington, the disease loss was much heavier in western Washington (76 percent vs. 17 percent). Aycock (10) stated that "The springs of 1955 and 1956 were very conducive to Stromatinia infection in North Carolina when several prolonged periods of low temperatures occurred during the early part of the growing season. Many plants often recover when the weather becomes warm and dry". Magie (47) reported that infected plants may only be stunted as a result of root infection during cool weather in Florida, but as the temperature rises to 75° or 80° for a few days the disease develops rapidly and severely. The disease occurs in Florida in fall and early winter but not in spring. In California Stromatinia produced symptoms on the new corms during the cooler months, but not during the summer (17).

Ryan (59) reported results of McClellan's on temperature tests in a greenhouse. Twelve percent of the corms were infected at 55°, 54 percent at 65°, 51 percent at 75°, and 29 percent at 85° F. A 95° temperature killed the corms. The reduced attack at warmer temperatures may be related to wound periderm formation as found by Marshall (51) in his tests.

In experiments in 1957 in Washington, using a tile method which is being described elsewhere, soil heating cables were used to maintain minimum temperatures of approximately 70° F in artificially infested soil, beginning May 3. Corms were planted May 15 and harvested October 21. The soil temperature in the control tanks was 50° at the time of infestation on March 11. This rose to 58° on April 30 and to 65° by July 29. The loss from dry rot in the heated soil was slightly more than in the unheated soil, although the yield of flowers, average weight, and total weight of corms also were greater under the warmer conditions (Table 1).

Within limits, temperature is undoubtedly an important factor in the infection and subsequent development of Stromatinia. However, if the temperature is not excessively high, then moisture appears to be the major determining influence. The fact that severe losses from dry rot appear to be more common under cool conditions may possibly be related to higher soil moistures that usually occur under such conditions.

Table 1. Effect of fungicidal treatment on the yield of flowers and corms of gladiolus planted in non-infested and dry rot infested soil, 1957. Results are the total yields from three replications of 100 corms each. Materials applied dry and rotovated into the soil unless indicated otherwise.

Soil	Number corms planted per tank.	Special condition	Fungicide[g] applied	Rate per acre active (lbs)	Number Flowers	Number corms harvested			Weight in grams	
						Healthy	Diseased	Total	Total	Av. per corm
Not infested -MSL[a]	50	--	None	--	84	128	11	139	1067	7.68
" "	100	--	None	--	19	277	12	289	3161	10.94
" "	"	--	Tersan[b]	300	6	276	10	286	2668	9.33
" "	"	--	Vapam[c]	436	18	282	11	293	2763	9.43
Infested - Silt	"	--	None	--	0	217	43	260	2146	8.25
" - MSL	"	--	None	--	0	157	38	195	1813	9.30
" "	"	70°	None	--	48	134	97	231	2395	10.37
" "	"	wet	None	--	0	192	30	222	1589	7.16
" "	"	--	Mylone	170	1	161	85	246	2737	11.13
" "	"	--	RE-4334[c]	200	0	167	57	224	2285	10.20
" "	"	--	Vapam[c]	436	2	203	72	275	2882	10.48
" "	"	--	Vapam[d]	436	3	195	75	270	2713	10.05
" "	"	--	Vapam & Tersan[e]	436	2	215	60	275	2675	9.73
" "	"	--	Thioneb	100	0	183	57	240	2279	9.50
" "	"	--	Tersan[f]	150	2	183	62	245	2164	8.83
" "	"	--	Tersan[b]	300	0	240	40	280	2541	9.08

[a] Medium sandy loam.

[b] Corms dipped in Tersan (11 pounds per 100 gallons) and Tersan mixed dry with soil on April 15. Tersan drench (300 pounds in 5445 gallons per acre) on June 14 and July 25.

[c] In 5445 gallons water per acre followed by water application of 10,890 gallons per acre.

[d] In 10,890 gallons water per acre followed by water application of 21,780 gallons per acre.

[e] As in [c] plus drenches of Tersan as in [b].

[f] Corms treated in Tersan at regular rate, but soil application at one-half the rate in [b].

[g] Fungicides tested:

Mylone 85W = (85%) 3,5-dimethyl tetrahydro-1, 3-5, 2H thiadiazine-2-thione.

RE-4334 = (4 pounds per gallon) N methyl-N nitroso-m-butyl carbamate.

Tersan 75 = (75%) tetramethyl thiuram disulfide.

Thioneb-50W = (50%) polyethylene thiuram sulfides.

Vapam 4-S = (31%) sodium N-methyl dithiocarbamate.

Moisture

Hawker et al. (33) found that the dry rot fungus grows only about 9 inches through the soil in a dry season, but almost twice as far in a wet season. Nelson (54) stressed the fact that dry rot is worse in poorly drained soils and under conditions of excessively heavy fall rains. Magie (37) stated that excessive moisture increases both neck and root rots in Florida. In that State the neck rot phase is usually rare in seasons with less than normal rainfall. However, root rot is occasionally severe even in seasons of subnormal rainfall when soil moisture is supplied by seep irrigation. In 1956 Magie (40) stated that the disease was important only on crops planted in well-drained soils. He indicated that summer flooding could greatly reduce the number of sclerotia surviving in soil.

Gould (30), in the field experiment described under temperature effect, reported average rainfall in the summer for western Washington as being about three times that for eastern Washington. Although irrigation water was supplied in both areas in sufficient quantities for satisfactory plant growth, the disease loss was 76 percent in western Washington vs. only 17 percent in eastern Washington.

Gould (unpublished data) in a greenhouse experiment in 1956 planted Spotlight corms in #10 cans in which holes had been punched at different heights to maintain different water levels. Water was applied as needed by overhead sprinkling. Three soil types (silt, peat, and light sandy loam) were used. Soil in one-half of the cans was infested with Stromatinia. The disease appeared soon after emergence, most severely in silt and least in peat. However, by harvest time, most of the corms in all infested soil types, and even some in non-infested sets (apparently caused by splashing from adjacent infested cans), were infected. The higher water levels, and silt and sandy soils, yielded the largest number of healthy corms, but the differences were very small in the infested sets. The best yields in non-infested soil were at the low water levels and in peat, followed by silt and sandy loam soils.

In the 1957 western Washington tile tests mentioned under temperature, soil in one set of tiles was given extra moisture. One acre-inch of water was added every Monday, supplementing normal rainfall and intermittent irrigation over the entire block. Excluding intermittent irrigation, for which no record was kept, the total amount of water applied to the "wet" tanks was 32.5 inches as compared with 10.5 inches for the others. The soil was moist also at the start of the experiment. In this test the supplemental moisture reduced the loss from dry rot, but also reduced the size of corms and total corm weight (Table 1).

In general, it appears that considerable moisture is necessary for optimum infection, but an excessive amount is harmful to the fungus, particularly under warm conditions.

Soil Type

In greenhouse experiments by McClellan (reported by Ryan, 59) the heaviest infection, 68.7 percent, occurred in coarse sand, as compared with 47.5 percent in fine sand, 44.1 percent in greenhouse loam, and 24 percent in heavy clay soil. A report (7) from Holland states that the disease is also more serious in sand than in clay in that country. In the 1957 Washington tile tests, the effect of silt and medium sandy loams was compared. The loss was much greater in sandy loam than in silt (Table 1).

Time of Planting

Magie (37) has observed that the neck rot stage is rare in Florida in plantings made either before September 1 or after January 1. Early plantings are necessary in western Washington in order to dig before the heavy fall rains commence.

Time of Digging

In 1946 Gould (30) found that digging in western Washington after October 8 resulted in more loss from dry rot than digging prior to that date. This was apparently caused by the higher moisture content of the soil after October 8. Observations indicate that increased rainfall is correlated with increased disease loss.

Nutrition

Marshall (50) tested different concentrations of nitrogen, phosphorus, potassium, magnesium, and boron for their influence on sclerotium production in culture. Potassium proved to be the most important element needed for rapid and abundant production. Magnesium and phosphorus also had a definite effect, but that of boron was only slight. A high level of nitrogen produced larger sclerotia than did a lower level.

Marshall (51) also studied mycelial growth of the fungus in different nutrient solutions. Effects of deficiencies of sulfur, zinc, and iron, were slight. Omission of copper (at 0.4 ppm) resulted in best growth, indicating that the fungus may be particularly sensitive to this element. Omission of molybdenum gave the next best growth. Deficiencies of magnesium, nitrogen, and phosphorus resulted in practically no growth, and lack of potassium and manganese yielded very little mycelium. (However, there appears to be some discrepancy between the text and the figure shown in regard to results with manganese.) Although high nitrogen resulted in better growth than low nitrogen, the difference was not significant. As growth increased in these tests, the pH increased from approximately 3.9 to 6.1. Results of pathogenicity tests with these cultures on corms were erratic and inconclusive.

Ryan (58) reported that in several instances insufficient boron had been correlated with increased dry rot. He and Ulman (63) also reported results obtained by Magie, who reduced losses under certain conditions by using boron either as a spray or soil fertilizer. Magie and Cowperthwaite (49) stated that dry rot was usually most severe where the soil or plants were deficient in boron. Gould (30) found that 60 pounds of borax on peat or 25 pounds on light sandy loam were injurious in western Washington, but that 12.5 pounds on light sandy loam slightly increased the yield of dry-rot free corms.

Previous nutrition of corms appears to have more effect on infection than does current nutrition, at least in western Washington. Thus, in an experiment in 1955, Gould (based on suggestions from Neil W. Stuart and W. P. Mortenson) added various fertilizers (N, NP, NPK, NP2K, NPKBo, & NPKMg) to artificially infested medium sandy loam and planted it with Picardy corms from a uniform, disease-free stock. The differences in yield of healthy corms were slight. A similar field test by Gould and Baur in 1954 with various combinations of nitrogen, phosphorus, and potassium gave similar results, although nitrogen slightly increased the loss and potash slightly decreased it.

However, in 1956 a test was run in western Washington using corms that had been grown the previous year in different nutrient solutions in sand at Beltsville by W. D. McClellan and Neil W. Stuart. Corms from 16 different combinations of high and low nitrogen, phosphorus, potassium, and magnesium were planted in artificially infested sandy loam contained in tiles at the Western Washington Experiment Station. Some differences in growth and disease response were apparent soon after emergence. Although high levels of either nitrogen or magnesium appeared to increase the loss from dry rot, the differences were not significant.

The experiment was repeated in 1957, using three varieties grown by Drs. Stuart and McClellan at Beltsville in 1956. The data are being analyzed and will be reported in a separate article. However, a preliminary tabulation indicates that previous nutrition with high levels of either nitrogen or magnesium again increased the loss from dry rot.

Effect of Curing Corms

Nelson (54) stated that rapid and thorough curing of the corms immediately after harvest would prevent the development of dry rot in storage. Observations and tests in western Washington have failed to show much benefit from such curing for dry rot control, although it has certainly proven essential in reducing losses from Botrytis corm rot. Magie (37) has expressed doubt that artificial curing is of much help in Florida.

CORM TREATMENT

Fungicides

Although the control of dry rot by corm treatment with fungicides is certainly far from perfect, a certain measure of success has been achieved. The benefit from such treatment may be as much a matter of keeping the fungus from growing out of diseased corms as in preventing penetration of adjacent healthy ones by a protective fungicidal coating. This supposition is based on the discovery by Massey (52) and others (33) that the fungus does not grow

directly into daughter corms from diseased parent corms, but instead grows through the sheathing leaf bases or out into the soil from which it attacks the new corms.

Moore (53) reported that corm treatment tests up to 1939 had not given very promising results. The best results had been obtained with mercurials. Hawker et al. (33) also found that certain mercurials were promising. An organic mercury was effective in France (4), and New Improved Ceresan (5 percent ethylmercury phosphate), Lyson (cresol) and corrosive sublimate worked well in Canada (68). Nelson (54) reported calomel (mercurous chloride) and yellow oxide of mercury best for treating corms for dry rot control.

In 1954 Magie (37) recommended the use of Dowicide B (sodium 2,4,5-trichlorophenoxide) and New Improved Ceresan. As a result of subsequent tests, he (43, 44, 46) has suggested either New Improved Ceresan or Ceresan M (N-(ethylmercuri)-p-toluene sulfonanilide). In his most recent trials (43, 44), Panogen (cyano(methylmercuri) guanidine) and Thimerosal (ethylmercury thio salicylate) have given very promising results but are not yet recommended for general use.

Young and Palm (74) recommended a 1-minute treatment in either New Improved Ceresan or Tersan. Recommendations in Australia (5, 19) call for a 48-hour soak in phenyl mercuric acetate solution or a dip in calomel. (Periodic sprays of Bordeaux during the growing season were also recommended in Australia (3).) In North Carolina, Haasis (32) found that the fungus was practically eliminated without any phytotoxic effects by treating corms soon after cleaning in a suspension of Ceresan M. He obtained fair control with Dowicide B and Dow 9B (zinc trichloro phenate), but New Improved Ceresan and Spergon (chloranil) were relatively ineffective. Ohio tests by Runnels (reported by Ryan, 60) showed that corm dips in solutions of mercuric chloride and Calogreen (mercurous chloride) were superior to Manzate (maneb), Dow 9B, or an Arasan (thiram) dust.

A multitude of compounds of many types have been tested in western Washington since 1944 as corm treatments for dry rot control (27, 28, 29, 30). The mercuries (particularly New Improved Ceresan) and phenols (such as Dowicide B) have generally given good results, but have sometimes resulted in considerable injury, probably because the corms are usually more succulent than those grown elsewhere under warmer and drier conditions. Thiram (in the form of Tersan at 11 pounds per 100 gallons) has given the most consistent increases in yield of healthy corms in this area (30).

Treatments of cormels with fungicides have generally given inconclusive control, but some rather spectacular results have been achieved recently with a hot-water treatment developed by Bald and associates.

Hot-Water Treatment of Cormels

Cormels can be freed from infection by several fungi, including Stromatinia, by using a hot-water treatment developed by Bald, Roistacher, and associates (14, 15, 16, 55, 56). Their experiments and pertinent literature reviews are thoroughly covered in a recent article (56). The following steps have been outlined by them (15), using cormels grown and dug under warm conditions: 1) warm curing followed by room storage for 2 months; 2) presoaking cormels in water at air temperature for 48 hours; 3) soaking in formaldehyde (1/200) for 4 hours; 4) treating in hot water (135° F) for 30 minutes followed by rapid cooling, drying and dusting with Spergon before storing. This treatment has been successfully used by several commercial growers in California.

In 1956 Magie (38, 39) indicated that the hot-water treatment appeared promising for use in Florida and he is now (42) recommending its use. However, Magie has found that cormels of certain varieties are killed by the treatment and therefore recommends making a trial test before large scale treatment of new varieties (43, 44).

Forsberg (25) has also found a variation between varieties in their susceptibility to heating injury. Generally, in his tests, the best time for treating cormels stored at 75° F was in January, but the optimum time varied with varieties. He concluded that "The hot water treatment of cormels has shown considerable promise, but more research is necessary before this method of disease control can be fully recommended".

Results by Gould (unpublished data) in western Washington were not encouraging, probably because soils in that area were usually cool at digging time. This is in line with Bald's (14) findings in California that only cormels grown under warm conditions could stand the treatment.

Roistacher et al. (57) have found that the stage of dormancy of cormels can be estimated by use of a triphenyltetrazolium chloride staining test.

The hot water method of freeing cormels from Stromatinia infection, coupled with the

possible development of treatments for infested soil, offer more encouragement for eventual control of dry rot than we have had for some time. However, in general, it appears that the hot water technique will be most successfully applied to cormels grown in the South because of their greater dormancy.

SOIL TREATMENT

Results Elsewhere

Hawker et al. (33) in small plot tests obtained good but not complete control by treating contaminated soil with mercuric chloride, Aretan, Uspulum, or formalin.

Magie (37) found in Florida that calcium cyanamid at 1500 pounds per acre substantially reduced the neck rot infection in fine sandy loam when it was applied at least 60 days before planting. Later, he reported (38, 41; also reported by Ryan in 59, 61) good control with Terraclor (pentachloronitrobenzene), Crag 974 (Mylone), and Vapam. Since his latest tests (43, 44, 46, 48) have confirmed their promising results, he now recommends these materials (particularly Vapam (VPM) and Crag Mylone) for use in Florida in soil known to be infested. Magie suggests testing the soil ahead of time to determine presence of the pathogen by planting healthy cormels in samples of soil obtained both from fields known to be "clean" and from the fields to be planted. DD and EDB were ineffective in Magie's tests.

In Canada, Thompson found (reported by Ryan, 64) that a soil treatment with Arasan (6 grams per cubic foot) plus a corm dip in Fermide gave better control of dry rot than a Vancide 51 drench or other treatments.

A small experiment during 1956 in Illinois made by Forsberg (24) with Mylone resulted in a statement that "Soil treatments for control of Sclerotinia rot are of doubtful value under Illinois conditions". In 1957 he (25) tested five soil fungicides (Terraclor, Mylone, Vapam, and Omadine (pyridinethione) zinc and copper salts) but the results indicated that "The use of soil fungicides for control of gladiolus diseases has not been demonstrated to be practical in Illinois".

Soil treatment experiments (9; also reported by Ryan in 61) in North Carolina in 1956 were generally unsuccessful because of the lack of suitably infested soil. Mylone, at 300 pounds per acre, delayed shoot emergence. However, neither it nor any of the other treatments reduced flower or corm yield significantly.

In recent Ohio tests (reported by Ryan, 62) Terraclor (100 pounds active per acre) yielded the most healthy corms, followed by Mylone (200 pounds) and Vapam (51 gallons).

Ferguson and Markley (23) controlled Stromatinia and certain other fungi in California by fumigating soil with methyl bromide at 2, 3, and 4 pounds per 100 square feet. Although increases in corm size and disease control were obtained with the use of pathogen-free planting stock, a poorer yield on fumigated soil was obtained when infested stock was planted, presumably because of the reduced population of competing microflora. Jefferson et al. (34) reduced, but did not eliminate, the loss from Stromatinia in a small scale test with Vapam in 1954-55.

Results in Western Washington

In western Washington Gould (30, 31, and unpublished) obtained excessive injury or insufficient control in field applications of Terraclor, nabam, Shell 51-P-162 (hexachlorocyclopentadiene), M-(Mathieson)1197 (2,4-dinitrochlorobenzene), M-273 (2,4,5-trichloro-1-nitrobenzene), M-276 (2,4,5-trichloro-1,3-dinitrobenzene), M-1484 (sodium salt of 2-pyridinethione-1-oxide), Penn Salt NP-1083 (1-fluoro-2,4-dinitrobenzene), calcium cyanamid, and C & C 5400 (1,1′-trithiobis[N,N-dimethylthioformamide]). Field tests in 1955 (reported by Ryan, 59) showed that corm treatment combined with periodic drenches of thiram gave good control. In greenhouse tests by Gould during the winter of 1955-56, Vapam gave the best control; a thiram drench was next best and superior to drenches with maneb, zineb, or nabam. The following pyridinethione compounds were ineffective: 1456 (disulfide salt of 2-pyridinethione-1-oxide), 1563 (zinc salt of 2-pyridinethione-1-oxide), 1564 (manganese salt of 2-pyridinethione-1-oxide), and 1565 (ferric salt of 2-pyridinethione-1-oxide).

Artificially infested soil contained in large sewer tiles was used for the tests described below because uniformly large areas of infested field soil were not available. A manuscript is in press giving details of the procedure. Soil in which gladiolus had never before been grown was infested with giant oat cultures of the fungus. Subsequently, the soil was treated

and later planted with apparently disease-free corms. Although the corms came from supposedly clean stocks in both 1956 and 1957 and were, in addition, dehusked and carefully examined, the results indicated that a few internally-infected corms escaped detection in both years.

Results in 1956: In 1956 the soil was infested on April 16, treated on April 19 and planted on May 8. The results, in order of best disease control, were: Tersan (soil treatment followed by bimonthly drenches of 350 pounds), Vapam at 400 and 500 pounds, Mylone at 255 pounds, Vapam at 600, Vapam at 300, Vapam at 200 and Mylone at 128 pounds. All rates are in terms of weight of active material per acre. Although the Tersan gave the largest number of healthy corms, corms from certain Vapam and Mylone treatments had a larger average weight. With the higher rates of Vapam, apparently enough of the material was left in the soil to be phytotoxic in this test. It also delayed emergence in the greenhouse test in 1956, although the results in controlling dry rot were very promising.

Procedure in 1957: The methods used were similar to those in 1956. In addition to the fungicidal treatments, certain studies on moisture, temperature, and soil type were made. Results of these have already been briefly summarized. Three replications were used. The variation between them was somewhat greater than had been experienced previously. Also, the disease losses were lower than usual, particularly as compared with 1956. The lower average summer temperatures in 1957 may have been responsible for the decreased loss.

Soil was infested on March 11 and treatments were made on April 15. A quantity of sterilized oats equal to that used for infesting purposes was added to the non-infested tanks on April 15. The Vapam-treated-infested soil was rotovated on May 15, 8 hours before planting. Corms (size 5 of the Spotlight variety) were planted on May 15 and were harvested on October 21.

The only corms treated were those used in the Tersan sets, with a five minute dip at a rate of 8.2 pounds (active) in 100 gallons of water. Tersan drenches were applied to the soil surface on June 14 and July 25. Results are given in Table 1.

Results in 1957: The results presented in Table 1 show that all treatments in infested soil were helpful in some way. The main results from the best treatments were as follows:

1. In number of healthy corms: Tersan was best, followed by Vapam.
2. Weight of all corms: Vapam, followed by Mylone and Tersan.
3. Average corm weight: Mylone, followed by Vapam, RE-4334, Thioneb and Tersan. (In general, there was an inverse ratio in the best treatments between the number and size of corms, probably because of competition for growth.)
4. The regular Vapam treatment was not improved by doubling the amount of water. The addition of two drenches of Tersan to the regular Vapam soil treatment slightly increased the number of healthy corms.
5. The regular Tersan application was definitely superior to a rate one-half as strong.
6. Tests in non-infested soil showed that apparently there is no benefit and perhaps even some slight harm in treating "healthy" soil with either Tersan or Vapam at the rates used. However, in the latter case, the soil was not rotovated before planting. Thus, the material could have persisted in sufficient amounts to have been phytotoxic.
7. Reducing the number of corms planted in "healthy" soil from 100 to 50 resulted in a considerable increase in flower production, an associated reduction in average corm weight and yield, and an unexplained slight increase in disease loss from natural corm-borne infection.

Discussion of Results in 1957: Vapam and Tersan produced the best overall results and definitely improved yields over those on untreated soil. The degree of control was not so great as was hoped for and neither material is considered to be the final "answer" to the soil-borne phase of the dry rot problem in western Washington. Even so, the results are sufficiently promising to justify suggesting both Tersan and Vapam for trial use, if growers believe their use to be economically feasible. Results in 1956 and 1957 indicate that the minimum rate of Vapam (or VPM) should be about 400 pounds per acre and that of thiram about 300 pounds active. At such rates the cost would be excessive for most commercial operations, but would be more practicable for amateurs who are restricted usually to small areas near or at their homes.

Based upon results in 1956 and 1957, it appears that the waiting period in western Washington between treating with Vapam (or VPM) and planting must definitely be longer than the 2

weeks often recommended elsewhere. This is substantiated by results with Vapam on other ornamental crops in western Washington. Commercial recommendations (35) now call for a minimum interval of 3 weeks between treating and planting with VPM (or Vapam) under normal conditions, and 4 weeks after heavy rainfall or in heavy soils. The soil surface should be broken about 5 to 10 days after treating to allow fumes to escape. Rates vary from 1 to 3 pints per 100 square feet. The injection method now recommended in Florida (46) and elsewhere (35, 67) might also give better results than the drench application used in these tests. Vapam might also be more effective in western Washington if applied in the summer at warmer temperatures.

Results with Tersan were not so good as in preceding years, perhaps owing to a lower summer temperature. Tersan also apparently reduced the average corm size slightly in both 1956 and 1957.

Although the soil was moist when the Mylone was applied, an additional water seal might have helped with that material. Also, in view of our 1956 tests, a higher rate might have given better results. The commercial recommendations (75) now call for 290 pounds active Mylone per acre, distributed over the surface and drenched into the soil or rototilled in with a subsequent light water seal. Three weeks should elapse before planting.

Methyl bromide has not been tested in western Washington against Stromatinia but it would likely be effective and is worth testing in locations where its use would be economically feasible.

Recommendations

Based upon the results here and those elsewhere, the following suggestions are made for trial use in controlling dry rot of gladiolus in western Washington, bearing in mind that the most recent and promising experiments in this region have been confined to "tile testing" over a 2-year period.

1. Discard all diseased corms from lightly-infested stocks and all corms of severely infested stocks.
2. Dip corms for 5 minutes in thiram (8.2 pounds active per 100 gallons water) just before planting.
3. Plant in heavy, but well-drained soil.
4. Avoid excessive amounts of nitrogen and ma$_{\text{u}}$esium.
5. Plant in non-infested soil preferably, or on infested soil treated on a trial basis with one of the following materials before planting. For amateur use, an overall application is preferred to a band application.
   A. Thiram mixed with soil at a rate of 300 pounds active per acre and drenched every 2 months with a water suspension at the same rate.
   B. Vapam (or VPM) injected or drenched at a rate of 400 pounds active per acre in 5445 gallons water and washed into the soil with 10,890 gallons water. The soil should be loosened 2 weeks after treating and 2 weeks before planting to aid escape of fumes. Follow manufacturer's directions carefully.
   C. Methyl bromide fumigation at 2 pounds per 100 square feet according to manufacturer's directions. This treatment is best done by a custom operator, because of the danger from improper use of the gas.
6. Dig corms as early as practicable and cure rapidly at 80 to 90° F. Clean and store under cool, dry conditions.

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SOME PREVIOUSLY UNREPORTED NON-WOODY HOSTS OF ARMILLARIA MELLEA IN CALIFORNIA

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The oak root fungus, Armillaria mellea (Vahl) Quél., is known to have a wide host range, consisting mainly of woody plants. Although not so common on non-woody or herbaceous plants, it sometimes attacks such plants. Recent investigations have revealed some additional hosts of this type in California. The plants reported were found to be naturally infected and are thought to be new hosts except where noted.

The plants infected and the locations are as follows: Amaryllis vittata Ait., Santa Clara; Fuschsia hybrida Voss, Berkeley and San Francisco; Impatiens oliverii Wright, Berkeley; Pelargonium domesticum Bailey, Berkeley and Oakland; and Pelargonium peltatum Ait., Santa Rosa.

Infected plants of the hybrid amaryllis (A. vittata) were found in a bed planting in which some of the plants were dying. Upon examination, the fungus was found to be permeating the infected bulb.

In the Impatiens plant, the fungus was found to be developing outside the cambium layer of the lower stem, as it does typically. This plant, however, has relatively large watery pith in which the mycelial plaques had advanced about 6 inches farther than they had outside the cambium.

Since fuchsia and Martha Washington type geraniums (P. domesticum) grow as perennials in California and tend to become somewhat woody, they may not be considered as herbaceous plants. However, both of these plants have been found infected in various stages of growth, including the young succulent stage. One older P. domesticum plant was found in which the fungus had grown from the somewhat woody tissues at the base of the plant into the more succulent tissues of the branches.

Fuchsia has been included as a susceptible host in an unpublished list by Dr. Harold E. Thomas. In addition, other species of Pelargonium have also been reported to be susceptible. They include P. capitatum (3), rose geranium (P. graveolens) (2), and P. hortorum (1). The last-named was noted only as susceptible when used as a test plant in inoculation studies. Natural infection of this species has also been found in the San Francisco Bay area.

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CHEMICAL EXCLUSION OF MITES FROM LABORATORY FUNGAL CULTURES

E. A. Curl

Abstract

Results of laboratory tests showed that a 3.0 per cent solution of Kelthane, 1, 1-bis(chlorophenyl)-2, 2, 2-trichloroethanol, sprayed on simulated laboratory shelves satisfactorily excluded the mite, Tyrophagus lintneri (Osb.), from plates of fungal cultures. The miticidal residue was still effective 14 days after application. Spraying isolation and incubation areas once a week with a 3.0 to 3.5 per cent solution of Kelthane EC was adopted as standard laboratory procedure for eliminating mite infestations.

Incorporation of Kelthane into potato dextrose agar at concentrations not exceeding 1.0 per cent may be useful for routine isolation work. However, the chemical had inhibitory effects on several soil fungi.

Contamination of laboratory fungal cultures by mites has been a serious problem for many years. A number of methods have been suggested for control of such mites. Carpenter (2) treated cotton plugs in test tubes with a solution composed of alcohol, mercuric chloride, and glycerine. Jewson and Tattersfield (6) controlled mites effectively with pyridine, but found it to be slightly toxic to fungi. Shafik and Page (7) obtained satisfactory control by exposing infested cultures to carbon tetrachloride for 24 hours. Successful control by mechanical barriers has been reported by Hansen and Snyder (5) and by Snyder and Hansen (8). Elliott (3) used paradichlorobenzene absorbed on blotting paper in fungal cultures.

Most of the mite infestation in this laboratory has occurred in a constant temperature, incubation room where the temperature (26°C.) seems to attract the mites or favor their rapid reproduction. Kelthane, 1, 1-bis(chlorophenyl)-2, 2, 2-trichloroethanol[1], was selected for a series of tests because of its effectiveness in control of several species of mites on crop plants (1, 4, 9).

METHODS

The mite used in the following tests was identified as Tyrophagus lintneri (Osb.)[2]. Mites were cultured in Petri plates containing mixtures of abundantly sporulating species of Trichoderma, Aspergillus, and Penicillium. These plates then served as the mite source for the tests.

In the first test, smooth, hard-finish asbestos boards were sprayed, by means of a small bottle, plunger-sprayer (Windex), with concentrations of 3.0, 2.0, 1.0, and 0.5 per cent Kelthane. A fifth board, which was not sprayed, served as a check. The boards were elevated on inverted beakers that stood in pans of water to prevent escape of the mites. Twelve plates of sterile potato dextrose agar (PDA) were placed in 2 stacks of 6 plates each approximately 4 inches from a stack of 7 mite-infested plates on each of the boards. Each group of plates was covered with rigid plastic covers. After 5 days, the number of mites in each PDA plate and the number of plates with fungal-bacterial contamination were determined. Then, after an interval of 9 more days, the plates were examined again.

In the second test, Kelthane was incorporated in PDA at concentrations of 1.0, 0.5, and 0.25 per cent, autoclaved at 15 pounds pressure for 20 minutes, and plates poured. Three 6-plate stacks of mite-infested fungal cultures were placed on clean boards around and approximately 4 inches from a 12-plate stack of agar plates that contained one of the concentrations

[1]Kelthane EC, emulsifiable concentrate, was furnished by the Rohm and Haas Company, Washington Square, Philadelphia, Pennsylvania.

[2]The mite was identified by E. W. Baker, United States Department of Agriculture, Insect Identification and Parasite-Introduction Laboratories, Beltsville, Maryland.

Table 1. Numbers of mites occurring in plates of potato dextrose agar on platforms that were sprayed with different concentrations of Kelthane.

Plate No.	Number of mites in plates				
	3.0 per cent	2.0 per cent	1.0 per cent	0.5 per cent	0 per cent
1	0	0	3[a]	0	11[a]
2	0	1[a]	6[a]	0	6[a]
3	0	0	0	0	5[a]
4	0	0[a]	3[a]	0[a]	10[a]
5	0	0	4[a]	6[a]	30[a]
6	0	6[a]	10[a]	1[a]	25[a]
7	0	1[a]	0[a]	0[a]	15[a]
8	0	0[a]	1[a]	0[a]	12[a]
9	0	0[a]	1[a]	0	11[a]
10	0	1[a]	0[a]	0	7[a]
11	0	0[a]	2[a]	5[a]	8[a]
12	1[a]	2[a]	5[a]	11[a]	10[a]
Total	1	11	35	23	150

[a]Plates were contaminated by mite-transmitted fungi and bacteria.

Table 2. Growth of soil fungi on potato dextrose agar containing two concentrations of Kelthane as compared to growth on medium without the miticide.

Fungus	Average diameter of colonies in mm. at designated miticide concentrations and time intervals[a]								
	0 per cent[b]			0.25 per cent			1.0 per cent		
	56 hr.	68 hr.	80 hr.	56 hr.	68 hr.	80 hr.	56 hr.	68 hr.	80 hr.
Fusarium oxysporum f. vasinfectum	25	45	68	29	53	85	19	34	52
Sclerotium bataticola	10	11	15	13	14	16	8	9	11
Trichoderma sp.	68	90	90	44	90	90	30	73	90
Sclerotium rolfsii	46	90	90	15	47	77	14	40	68
Diplodia sp.	87	90	90	35	63	89	33	63	89
Botryodiplodia sp.	90	90	90	83	90	90	70	89	90
Cylindrocladium scoparium	29	48	74	20	32	46	17	28	41

[a]Figures are averages of 4 replications.
[b]Untreated check.

of miticide. Agar plates without the miticide served as checks. At the same time, other mite-infested cultures were placed alternately in stacks with plates containing the miticide. Thus, a large number of mites were concentrated in a small area, and had only a few inches to move to enter the agar plates. After 5 days data were recorded.

In a third test, the effect of Kelthane in potato dextrose agar on growth of several soil fungi was tested. Plates of PDA containing concentrations of 1.0 and 0.25 per cent of miticide were inoculated in the centers with each of the fungi. These were incubated at 26°C, and the diameters of growing colonies were measured at intervals.

RESULTS

Results of the first test are presented in Table 1. After 5 days, only one mite had entered one agar plate on the platform that was sprayed with 3.0 per cent Kelthane. This plate was the bottom plate of a stack. A second examination after 14 days revealed that the residue of the 3.0 per cent concentration was still effective. Miticide concentrations of 2.0, 1.0, and 0.5 per cent sprayed on the boards did not prevent mites from entering the plates. A number of the plates had no mites, but trails of bacterial and fungal contamination indicated that they had entered. The stack of plates on the unsprayed board had more than twice as many mites as all other plates combined.

In the second test, only one PDA plate of each miticide concentration was contaminated where these plates were stacked separately from mite-infested plates. Where treated plates were stacked alternately with mite plates, even the 1.0 per cent concentration of Kelthane allowed contamination of 5 of the 12 plates in the stack. All plates containing no miticide were contaminated and some of the mites were still present. The majority of treated plates, which mites had entered, contained small spots of contamination only at the edge of the agar, indicating that the mites had barely touched the agar and departed.

The effect of Kelthane incorporated in potato dextrose agar upon growth of seven soil fungi is shown in Table 2. Fusarium oxysporum f. vasinfectum and Sclerotium bataticola appeared to be slightly stimulated to more rapid growth in medium containing 0.25 per cent miticide, but growth was retarded by 1.0 per cent miticide. The other fungi were inhibited to some extent by both concentrations of Kelthane. Sclerotium rolfsii and Diplodia sp. were most retarded. Where the miticide was used in the medium, S. rolfsii colonies became very irregular or distorted, and did not produce sclerotia within 80 hours as compared with abundant sclerotium production in plates without miticide.

CONCLUSIONS

On the basis of these results, a routine method of controlling mites in this laboratory was adopted. During the summer months in particular, all laboratory tables and shelving are sprayed with a 3.0 to 3.5 per cent solution of Kelthane EC twice each month. The inside of the constant temperature isolation-incubation room, where most of the fungal cultures are stored, is sprayed once each week. Since this control practice was begun, no more trouble with mite infestation has been encountered.

Incorporation of Kelthane into media is not recommended where growth and other activities of fungi are to be studied. It might be of value, however, for routine isolations from plant material. A note of caution should be added. Agar plus Kelthane at concentrations exceeding 1.0 per cent tends to be inflammable. This is evidenced when a bottle or tube of such agar is flamed prior to pouring plates.

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SOIL-BORNE VIRUSES FROM CHRYSANTHEMUM AND BEGONIA

Philip Brierley and R. V. Travis[1]

Summary

Soil-borne viruses isolated from Market Orange and Shoesmith chrysanthemum varieties and from begonia leaves differ from previously described viruses of the tobacco necrosis group in infecting tobacco systemically and in failing to infect bean or cowpea. Strains of cucumber mosaic virus accompanied two of the three soil-borne viruses. Some properties and hosts of these viruses are reported.

In August 1957, during routine indexing of English chrysanthemums for tomato aspermy virus, one of three tobacco plants inoculated from the variety Market Orange developed ring and etch patterns. In September 1957, Belgian begonia leaves were received showing light- and dark-green mottling with conspicuous dark-green blotches. Also in September 1957, C. F. Olson, Yoder Bros., Inc., Ashtabula, Ohio, supplied tobacco plants infected with "severe etch" isolated from the English chrysanthemum variety Shoesmith in the aspermy index made by Yoder Bros. Isolates from all three hosts included soil-borne viruses of the tobacco necrosis group. The Market Orange isolate proved to be a single entity. The isolates from begonia and from Shoesmith included with the soil-borne viruses aphid-borne components of the cucumber mosaic virus group. Some properties and hosts of these viruses are reported.

THE MARKET ORANGE VIRUS

The Market Orange virus was isolated from recently expanded leaves of a symptomless chrysanthemum of this variety ground in a small amount of .05M K_2HPO_4 and wiped over leaves of Samsun tobacco plants previously dusted with carborundum. Repeated attempts to isolate this virus from cuttings of this chrysanthemum failed.

In Turkish tobacco, Nicotiana tabacum L. var. Samsun, gray-ring local lesions appear after 3 to 4 days (Fig. 1A); white etch follows 10 to 14 days after inoculation (Fig. 1B). A month after inoculation green mottling predominates (Fig. 1C) and etch is inconspicuous or lacking. Symptomless upper leaves sometimes develop on plants with long-standing infection.

The Market Orange virus is local and symptomless in Blazing Gold, Dynamo, Good News, and Shoesmith chrysanthemums, as well as in the Market Orange source variety. Similarly, it is local and symptomless in Cramer's hybrid cineraria, Senecio cruentus DC.; in Marketer cucumber, Cucumis sativus L.; in Holborn Glory sweet william, Dianthus barbatus L.; in Begonia sp., a fibrous-rooted variety; and in Marglobe tomato, Lycopersicon esculentum Mill. The virus was reisolated from roots of inoculated Marglobe tomato but not from those of inoculated Shoesmith chrysanthemum. It produces ring-type local lesions only in Nicotiana glutinosa L. (Fig. 1E) in 3 days after inoculation; in Datura stramonium L. (Fig. 1G) in 4 days; in California Wonder pepper, Capsicum frutescens L.; and in Chenopodium amaranticolor Coste & Reyn. (Fig. 1F). In 5 days Golden Gem zinnia, Zinnia elegans Jacq., develops chlorotic spots and rings as local lesions (Fig. 1D) followed by systemic yellow mottling. Cheviot Maid snapdragon, Antirrhinum majus L., develops chlorotic spots and rings as local lesions and sometimes systemic chlorotic rings. The Rubra variety of Gomphrena globosa L. develops inconspicuous gray fleck local lesions in 6 days; systemic yellow blotching follows. The virus was reisolated from plants of each of these kinds.

No symptoms appeared in inoculated plants of Bountiful snap bean, Phaseolus vulgaris L.; Black Eye cowpea, Vigna sinensis (Torner) Savi; Callistephus sinensis (L.) Nees; or a tuberous-rooted variety of Begonia sp. All attempts to reisolate the virus from inoculated leaves of these plants failed.

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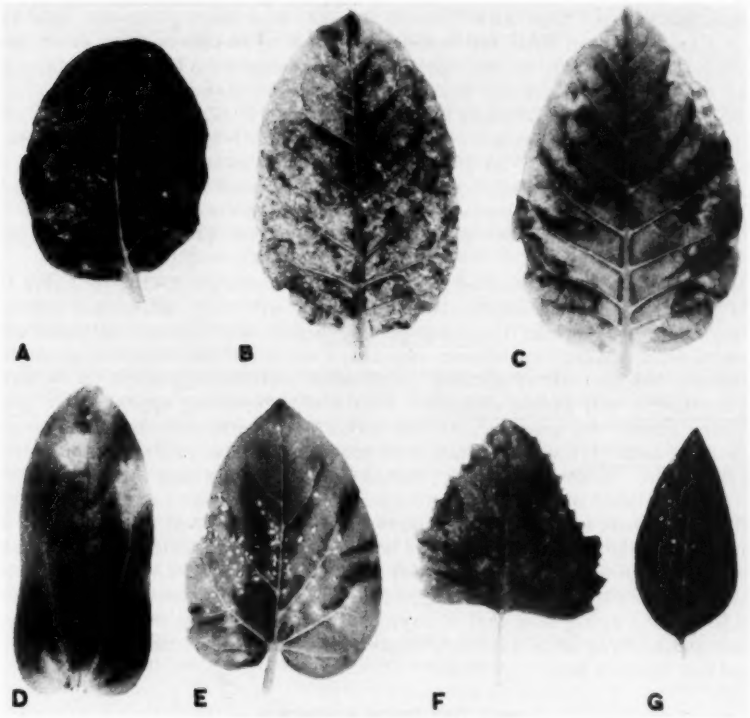

FIGURE 1. Symptoms caused in several host plants by a tobacco necrosis virus: A - C -- In Turkish tobacco local lesions in 4 days (A), white etch in 10 to 14 days (B), and green mottling in 1 month (C). D -- Chlorotic spots and rings in zinnia. E -- Local lesions in Nicotiana glutinosa. F -- Local lesions in Chenopodium amaranticolor. G -- Local lesions in Datura stramonium.

Soil Transmission of the Virus: Soil in which diseased plants had grown was freed of larger root residues, mixed, and placed in thumb pots. Twenty-five Samsun tobacco seedlings were transplanted from a seed pan into these thumb pots and allowed to grow for 8 weeks. No symptoms appeared in the leaves of these tobacco plants. At the end of the 8-week period the tops and roots of these plants were tested separately by sap inoculation to tobacco. On transfer from roots strong symptoms (rings, etch and mottle) developed; transfers from the tops yielded no virus.

Physical Properties of the Virus: The properties of the Market Orange virus were determined in February and April 1958. The thermal inactivation point fell between 90° and 92° C, dilution end point above 10^{-6}, and aging at room temperature, about 20°, exceeded 75 days, the longest period tested. The principal break in dilution tests came at 10^{-4} to 10^{-5}, but scattered infections appeared at 10^{-6}.

THE SHOESMITH VIRUSES

Tobacco plants supplied by C. J. Olson in September 1957 showed symptoms of "severe etch" obtained on indexing the English chrysanthemum Shoesmith for detection of tomato aspermy virus. Olson's attempts to recover this virus from Shoesmith at a later time failed. This experience is in agreement with our findings with the Shoesmith virus and the Market Orange virus and is explainable by the fact that these viruses are local in chrysanthemum.

The "severe etch" culture proved to be a complex of a soil-borne component and a virus of the cucumber mosaic group. The latter infects Datura, Nicotiana glutinosa, and cucumber systemically; it was separated from the soil-borne virus by subinoculation from systemic infections in these hosts. The soil-borne component was separated by heating or aging the virus complex beyond the tolerance limits of the cucumber mosaic component.

The soil-borne component withstood heating to 92° to 94° C, dilution to 10^{-5}, and aging for 105 days, the longest period tested. Tests were run in February and May 1958. The principal break in dilution came at 10^{-4} to 10^{-5}, but occasional infections occurred at 10^{-5}. In a soil-transmission test made in parallel with the Market Orange virus described in the preceding section 25 tobacco plants developed etch symptoms in leaves from exposure to root infection. This is exceptional for ten other plants tested at random yielded no virus from tops but a high titer from roots.

The cucumber mosaic virus infected Marketer cucumber, producing mottling in 5 days; dwarfing but no stem necrosis followed. Green mottling with mild white etch appeared in Samsun tobacco after about 9 days. In Nicotiana glutinosa yellow mottling was accompanied by dwarfing and white etch. Marglobe tomato expressed mild yellowish mottling and had some "shoestring" leaves, but no fruit symptoms. Systemic mottling appeared in Physalis angulata L., Datura stramonium, and Zinnia elegans. Mild yellow spotting appeared in Gomphrena. In cineraria, China aster, and snapdragon, the virus was systemic but caused no symptoms. In Chenopodium amaranticolor and in Black Eye cowpea local lesions of the cucumber mosaic virus type were formed. In Shoesmith chrysanthemum the virus was local, symptomless, and recoverable from inoculated leaves only. No symptoms appeared in Emilia sagittata (Vahl) DC., Bountiful bean, sweet william, or fibrous- or tuberous-rooted begonias; the virus was not recoverable from these plants. The virus was slowly systemic in Golden Gem zinnia, Zinnia elegans, but protected this plant against superinfection by Price's tester strain of cucumber mosaic virus. Properties determined in tobacco in June were heating, 65° to 70° C, dilution 10^{-4} to 10^{-5}, and aging less than 5 days. The tobacco strain of Myzus persicae (Sulz.), fasted for 1 hour and allowed an acquisition feeding of 5 minutes, transmitted this virus from tobacco to six of ten tobacco plants in June.

THE BEGONIA VIRUSES

Several begonia leaves from Belgium showed light- and dark-green spotty mottling with conspicuous roughly circular dark-green blotches. Apparently these leaves represented more than one species of begonia including the Multiflora type. Because tomato spotted wilt infection was suspected, sample leaves were ground in 0.5 percent Na_2SO_3 and the resulting suspension was rubbed on leaves of Samsun tobacco. Two of four leaves sampled produced gray rings in the inoculated tobacco and yellow mottling followed. Further subculture showed a complex of a soil-borne constituent together with a cucumber mosaic virus. No tomato spotted wilt virus was isolated, but this virus may have been present in the begonia leaves, which were partly dried and unfavorable for its detection.

The soil-borne component was separated from the complex through its greater tolerance of heat and aging. Properties determined in February, April, and May were as follows: heating 92° to 94° C, dilution end point 10^{-4} to 10^{-5} with occasional infections at 10^{-6}, and aging at room temperature, about 20°, 105 days, the longest period tested. The host range agreed closely with that of the Market Orange virus. In soil-transmission tests in parallel with the Market Orange and Shoesmith viruses tobacco exposed to root infection developed no symptoms in leaves. Subinoculation from these test tobacco plants detected no virus in tops, but a high titer of the begonia virus in roots.

The cucumber mosaic component was separated by subinoculation from systemic infections in Datura, Nicotiana glutinosa, or cucumber. In Marketer cucumber the virus caused gray local lesions in cotyledons followed by yellow mottling and dwarfing, but no stem necrosis. It invaded Marglobe tomato systemically and caused mild mottling and yellow spotting in mature leaves, but no fruit symptoms. In Datura chlorotic blotch local lesions were followed by spotty yellow mottling and white watermark. Nicotiana glutinosa responded with green and yellow mottling and leaf distortion. The virus invaded both fibrous- and tuberous-rooted begonias, causing mild yellow mottling in leaves and mild breaking of flower color. Snapdragon, Gomphrena, and Emilia sagittata developed yellow blotches that tended to fade. Cineraria carried the virus systemically without symptoms. Zinnia elegans developed a mild yellow mottling which protected it against superinfection by Price's tester strain of cucumber mosaic virus. The virus was reisolated from each of the test species named.

Chenopodium amaranticolor and Black Eye cowpea developed local lesions of the cucumber mosaic virus class. No symptoms appeared in inoculated China aster, Dianthus barbatus, or Bountiful bean, and the virus was not recovered from these plants.

Myzus persicae transmitted the virus in the non-persistent manner from tobacco to three of ten Samsun tobacco plants. Properties of this virus were not determined. On the basis of host reactions, cross protection, and aphid transmission this virus is a typical cucumber mosaic virus strain.

DISCUSSION

The soil-borne viruses from Market Orange and Shoesmith chrysanthemums and from begonia agree closely. They clearly belong to the tobacco necrosis group of viruses, but differ sharply from those previously studied (1, 2, 4, 5, 6, 7) in that they invade tobacco systemically and in that they fail to infect bean or cowpea. Since the tobacco necrosis group already includes several serologically unrelated viruses (1) there should be no objection to broadening the group somewhat further.

Because experimental evidence indicates these viruses are strictly local in chrysanthemum, it is surprising that they were detected in routine indexing for tomato aspermy virus. In Olson's experience as well as ours, tip cuttings from infected chrysanthemums are free from these viruses. Also we failed to detect these viruses in chrysanthemum roots. There would seem to be little danger that these soil-borne viruses will be maintained in commercial propagation of chrysanthemums.

The aphid-borne virus from Shoesmith chrysanthemum appears to be a strain of cucumber mosaic virus. This is the first time we have encountered a true cucumber mosaic virus from chrysanthemum. Attempts to infect Good News chrysanthemum with Doolittle's type of cucumber mosaic by juice inoculation or by Myzus persicae transfer were without success.

We have attempted to eliminate the soil-borne viruses from our greenhouse by steaming benches, pots and tools. The viruses, however, have been freeze-dried by McKinney's (3) method in case they should be of interest to other workers.

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A VIRULENT STRAIN OF CUCUMBER MOSAIC VIRUS FROM EASTER LILY

Philip Brierley and R. V. Travis[1]

Summary

A virulent strain of cucumber mosaic virus was isolated from Easter lily seedlings grown in Oregon for 1 year. Symptoms in tobacco suggest a complex of a mosaic and a ringspot virus, but the symptoms produced were not changed by passage of the causal agent through several host plants, by Myzus persicae transmission, or in property studies. The Easter lily virus has the properties of cucumber mosaic virus and protects zinnia against superinfection by Price's tester strain of this virus. It caused no symptoms in virus-free White Queen Easter lily, but was reisolated. Symptoms in Creole Easter lily are brown blotches and stripes which coalesce and produce early death of leaves. Symptoms in the Croft variety are similar but milder than those in Creole.

In June 1957, S. L. Emsweller handed us some Easter lily seedlings returned from Corvallis, Oregon, after 1 year's trial at Oregon Agricultural Experiment Station. Two seedlings showed prominent brown streaking along the midribs of the leaves. Sap inoculation from these plants to tobacco produced gray or brown ring local lesions followed by white to brown etch patterns, yellow mottling, and leaf distortion. The initial ring symptoms (Fig. 1, F), more prominent than usual for a cucumber mosaic virus strain, suggested that a ringspot virus might be present in a complex infection. Therefore inoculations were made to various test plants in an attempt to screen out a ringspot virus; Myzus persicae (Sulz.) transmission was tested as a means of eliminating the supposed ringspot virus; and property tests were made to see whether two component viruses might separate at different end points.

In 5 to 7 days Gomphrena globosa L. developed solid-gray local lesions followed by blotchy yellow mottling, and in 5 to 7 days snapdragon, Antirrhinum majus L., developed chlorotic spots followed by systemic chlorotic blotches. In 4 days Nicotiana glutinosa L. expressed gray-dot local lesions followed by yellow mottling with marked dwarfing. Marglobe tomato developed no local lesions, but epinasty, yellow blotches in leaves, and necrotic streaks along midribs appeared. Affected plants were dwarfed, but fruits were normal; the "shoestring" symptom characteristic of several strains of cucumber mosaic virus was lacking. Marketer cucumber developed chlorotic-ring local lesions in 3 to 5 days; in 10 days after inoculation mottling, dwarfing, and stem necrosis followed. Zinnia elegans Jacq. formed no local lesions but expressed yellow mottling in 10 days; infected plants were protected against superinfection by Price's tester strain of cucumber mosaic virus. Chenopodium amaranticolor Coste & Reyn. developed gray pinpoint local lesions in 3 days; in 10 days systemic yellow flecking followed. Emilia sagitatta (Vahl) DC. expressed yellow local lesions in 10 days and systemic blotchy mottling in 3 weeks. Datura stramonium L. produced chlorotic-spot local lesions in 6 days, and cowpea, Vigna sinensis (Torner) Savi, brown pinpoint lesions in 3 days. The virus was recovered unchanged from each of the test plants listed. No infection resulted in Bountiful bean, Phaseolus vulgaris L.; fibrous-rooted or tuberous-rooted begonias, Begonia spp.; China aster, Callistephus sinensis (L.) Nees; or cineraria, Senecio cruentus DC.; and the virus could not be reisolated from these plants.

Symptoms in three Easter lily varieties are distinctive and unlike those characteristic of the usual strains of cucumber mosaic virus. The varieties Creole, Croft, and White Queen were inoculated in January 1958; all three bloomed 3 months later. White Queen, which was virus-free when inoculated, developed no symptoms through flowering time, but the virus was

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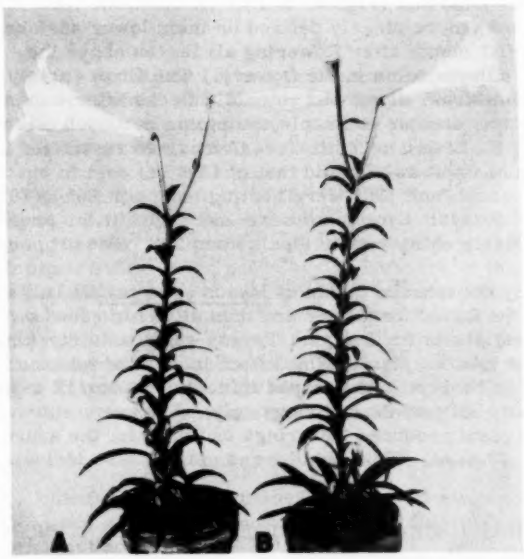

FIGURE 1. A, B -- Symptoms of a cucumber mosaic virus in Creole Easter lily at flowering time.
C, D, E -- Brown spots in Creole leaves, spreading along midribs.
F -- Local lesions in Turkish tobacco.

reisolated unchanged. Creole, symptomless but carrying mottle[2] and latent[3] viruses, first showed brown spots in inoculated leaves after 2 months (Fig. 1, A-E). At the same time mild chlorotic flecking appeared in the upper leaves, more clearly defined on their lower surfaces. The brown areas extended and coalesced until 1 month after flowering all leaves above the point of inoculation were dead. There were no symptoms in the flowers. The Croft variety, symptomless but presumed to carry lily latent virus, developed chlorotic flecks after 1 month and, at flowering time, brown spots and streaks similar to Creole symptoms but much milder. Flowers were normal. Even after flowering the brown necrotic areas remained restricted in number and size and did not hasten maturity of Croft as they did that of Creole.

Physical properties determined in tobacco in June 1958 were heating end point 65° to 70° C, dilution 10^{-3} to 10^{-4}, and aging less than 5 days. Symptoms were unchanged at the property end points, indicating that the virus is a single entity rather than a complex. The properties are in the range for cucumber mosaic virus.

Transmission from tobacco to tobacco by the tobacco strain of Myzus persicae (Sulz.) was demonstrated in December 1957. Aphids were fasted for 1 hour and then allowed to feed on the source plants for 4 minutes and on the test plants for 2 days. Twenty-eight to thirty-nine apterous individuals were placed on each test tobacco plant. Nine of ten inoculated tobacco plants developed necrotic-ring local lesions in 10 days; one escaped infection. After 17 days eight plants expressed mosaic symptoms also, but one showed rings only. However, subinoculation from the rings excised from this plant produced both rings and mosaic; the source plant also developed mosaic symptoms after 27 days. Thus aphid transmission also indicates a single entity rather than a complex.

CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, BELTSVILLE, MARYLAND

[2]Brierley, Philip, and Floyd F. Smith. 1944. Studies on lily virus diseases; the mottle group. Phytopathology 34: 718-746.

[3]Brierley, Philip, and Floyd F. Smith. 1944. Studies on lily virus diseases; the necrotic fleck complex in Lilium longiflorum. Phytopathology 34: 529-555.

OBSERVATIONS OF THE HOJA BLANCA DISEASE OF RICE IN FLORIDA

Edwin H. Todd[1]

Atkins and Adair (1) and Green and Panzer (2) reported and described the occurrence of the hoja blanca (white leaf) disease of rice in Florida. As stated in these reports, several species of grass, including sugarcane, have been observed to show leaf symptoms similar to those of hoja blanca on rice. Thus, it was of interest to determine the relationship, if any, of this virus disease of rice to sugarcane.

Through the courtesy of Dr. Victor E. Green, severely diseased mature rice plants, Selection C. I. 9016, were collected from a field of the Everglades Experiment Station, Belle Glade, Florida, and transplanted into eight 5-gallon cans. These plants were maintained under strict quarantine in the pathology greenhouse at the U. S. Sugarcane Field Station, Canal Point, Florida, and were used as the source of inoculum. Attempts were made to transmit the hoja blanca virus mechanically to sugarcane on September 22 and on November 11, 1957. Similarly, certain strains of the sugarcane mosaic virus were used to inoculate rice. Both of the cross-inoculations were unsuccessful. Malaguti, Diaz, and Angeles (3) were also unsuccessful in attempts to transmit the hoja blanca virus mechanically to rice, corn, and tobacco. However, these workers were successful in transferring the virus to rice by using a leaf-hopper as a vector.

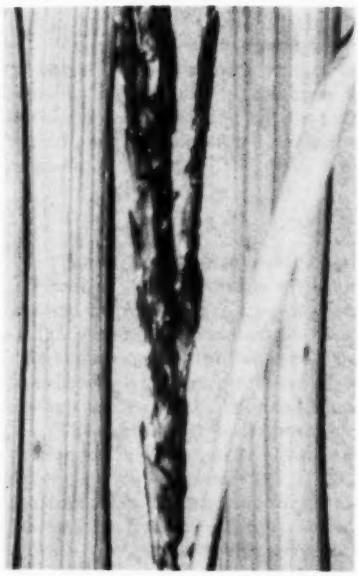

FIGURE 1. Representative sample of leaf and panicle effects of hoja blanca on mature plants of C. I. 9016.

FIGURE 2. Normal panicles and leaves of mature first stubble plants of C. I. 9016 that were initially severely affected by hoja blanca.

Following the above studies, the diseased rice plants were cut back to continue the inoculum source for additional cross-inoculation tests with rice and sugarcane that would involve the use of various insect vectors. The first stubble crop of these plants, however, showed no symptoms of the hoja blanca disease. In fact, the stubble plants in all eight cans appeared to be healthy and grew vigorously without fertilization. Furthermore, the effects of the disease were not apparent, as normal panicles of rice were produced. This indicated that, if present at all, the virus was not present in sufficient quantity for the symptoms or effects to be expressed. The plants were again cut back and a second stubble crop produced. Again, no symptoms or effects of hoja blanca were apparent and normal panicles and grain developed (Fig. 1, 2).

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These observations suggest the non-persistent nature of the symptoms of hoja blanca of rice, as indicated by field notations of Atkins and Adair (1) who stated that "...new tillers of a second or ratoon crop often show no symptoms."

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OBSERVATIONS OF TUBER TRANSMISSION OF ASTER YELLOWS (PURPLE-TOP) OF POTATOES[1]

L. T. Richardson and H. N. Racicot[2]

Abstract

The incidence of aster yellows (purple-top or bunch-top) was observed in five successive generations of indexed and nonindexed Green Mountain potatoes. Primary symptoms of the disease, resulting from current season infection, were found in field plants each season, but secondary symptoms, indicating tuber transmission, were found in a few index and field plants in the final season only. The distribution of these infected plants within each tuber unit indicated that the virus was not always uniformly distributed within the parent tuber. The virus was invariably transmitted from these plants to the succeeding generation through aerial tubers but never through subterranean tubers.

INTRODUCTION

Transmission of aster yellows (purple-top or bunch-top) of potatoes through subterranean or aerial tubers occurs rarely and inconsistently, according to the literature review by MacLeod (1). An opportunity to observe the incidence of this disease in five successive generations of potatoes was provided by the authors' previously reported investigation (2), wherein 1000 indexed and 1000 nonindexed Green Mountain tubers were planted as tuber units in the field each season.

OBSERVATIONS

Throughout the investigation typical primary symptoms of aster yellows, resulting from current season infection with the virus, frequently appeared late in the season on the apical growth of field plants grown from indexed and nonindexed tubers. In the final year a few plants in the greenhouse and in the field displayed acute secondary symptoms of the disease, indicating transmission of the virus from plants infected the previous season to this second generation through the parent tubers. All of the seed pieces from a tuber carrying the virus did not always transmit the disease, however, as shown by the distribution data presented in Table 1.

The second-generation symptoms of aster yellows became apparent as soon as the plants emerged from the soil. The plants were extremely stunted and had stiff, erect, rolled and chlorotic leaves (see Fig. 1, 2), resembling the condition described as "haywire". They remained alive throughout the season, however, and produced aerial tubers, subterranean tubers (up to 1 inch in diameter), and even a few seed balls. Figure 3 shows the tubers harvested from a unit planted with seed pieces from a tuber which had produced an infected index plant in the greenhouse.

When 35 of the miniature underground tubers from second-generation aster yellows plants were planted, every one produced an apparently healthy plant. When aerial tubers from the second-generation aster yellows plants were propagated in the greenhouse, on the other hand, every one produced an extremely dwarfed and spindly infected plant which nevertheless produced both aerial and subterranean tubers. These plants were harvested after they had apparently died, and were kept in a paper bag in a dark storage room at 40°F. When examined 1 month later it was found that fresh green growth had developed on one of these dry plants; new shoots extended from the aerial tubers and "shoe-string" proliferations appeared at each node on the stem (see Fig. 4). The underground tubers from these aborted plants again produced only healthy plants in the succeeding generation.

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FIGURE 1. Index plant grown in greenhouse from one eye of a Green Mountain potato tuber infected with aster yellows virus.

FIGURE 2. Field-grown potato plants showing typical second-year symptoms of aster yellows.

FIGURE 3. Tubers harvested from unit planted with four seed pieces from tuber which produced index plant shown in Figure 1.

FIGURE 4. Plant grown in greenhouse from aerial tuber produced by second-generation aster yellows plant in field. New shoots from aerial tubers and "shoe-string" proliferations at the nodes developed after harvest during month in dark, cool storage room.

Table 1. Distribution of plants showing secondary symptoms of aster yellows within units planted with seed pieces from seven indexed and six non-indexed tubers.

Indexing of parent tubers	Infection in index plant	Secondary symptoms in tuber unit plants			
Indexed	X[a]	X	O	X	O
	O	X	O	O	O
	O	X	X	X	X
	O	O	X	-	X
	X	X	X	X	X
	O	O	O	X	X
	O	O	O	O	X
Not indexed		O	X	X	X
		O	X	O	O
		O	O	X	X
		X	O	X	X
		X	X	X	X
		X	X	X	X

[a] X = diseased; O = healthy

True seed collected from field plants showing second-year symptoms of aster yellows was also planted in the greenhouse. Only two plants developed and both appeared to be normal.

DISCUSSION

These observations support the conclusion of MacLeod (1) that the aster yellows virus is not distributed uniformly throughout an infected potato plant. It is rarely present in an underground tuber, and then may be confined to part of that tuber. The extreme symptoms and peculiar behavior displayed by plants propagated from aerial tubers borne on second-generation aster yellows plants suggest that the virus may be concentrated in these organs. Quite different results have been reported from planting aerial tubers taken from plants infected the current season. No infected plants developed from 50 such aerial tubers planted by Younkin (4), and 2 of 20 plants propagated by Self and Darling (3) showed symptoms 40 days after emergence.

Since both healthy and infected plants can occasionally develop from the same tuber, it is not possible to detect, by tuber indexing, every tuber carrying the aster yellows virus. Because of its rarity tuber transmission of this virus is of negligible commercial importance, however, except that each infected plant in the field is a potential source of infection which may be disseminated by insect vectors. Such plants can be effectively eliminated by roguing because the striking symptoms are obvious early in the growing season.

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COMPARATIVE EFFICIENCY OF EXCISED LEAF-PETIOLE GRAFTS AND STOLON GRAFTS FOR TRANSMITTING CERTAIN STRAWBERRY VIRUSES[1]

P. W. Miller[2]

Grafting stolons of a tolerant variety to a susceptible one was first used by Harris (5) to index cultivated strawberry varieties for virus infection. In 1939, King (6) demonstrated that certain strains of Fragaria vesca L. are very sensitive to virus infection and can be used as virus indicators when their stolons are grafted to infected plants of cultivated varieties. From 1942 to 1956, this method was used almost universally for indexing strawberry plants for virus infection. In 1956, a new technique consisting of cleft-grafting excised leaves of the plant being indexed to F. vesca was described by Bringhurst and Voth (1). The terminal leaflet of a leaf of an indicator plant is removed, the petiole is split longitudinally, and an excised leaf petiole from the plant to be indexed is inserted and tightly wrapped with a commercial latex tape ("Sealtex"). In 1957, Jorgenson (7) described a technique for indexing strawberry plants for viruses by inserting a small piece of tissue taken from the petiole of the plant being indexed into a slit cut in the petiole of the indicator plant and wrapping the graft with latex tape.

In 1957, Fulton (3) reported that transmission with excised leaf-petiole grafts varied with each virus; more reliable results were obtained with the mild mottle strawberry virus than with virus C (epinasty virus) or with latent virus A.

In 1958, Cropley (2) reported erratic transmission of strawberry viruses by grafting excised leaves. However, the exact grafting technique used is not given and no mention is made of how long the excised leaves remained alive after they were grafted.

It is important to know definitely whether excised leaf-petiole grafts are as efficient in transmitting various strawberry viruses as stolon grafts since the former possesses a number of advantages not possessed by the stolon-graft technique. Some of the more important advantages are indicated here. There is no physical contact between the plant being tested and the indicator plant, and therefore there is no possibility of transmitting any vesca-latent viruses from a chance-infected indicator plant to the plant being tested and its progeny; this is particularly important in maintaining virus-free planting stocks. Grafting excised leaf petioles facilitates the indexing of plants for latent viruses; F. vesca plants infected with mild viruses (mottle virus, veinbanding virus or both) are needed to test for vesca-latent viruses; if such plants are directly grafted to plants being tested, infection of the clone would ensue. The first daughter plant can be removed and indexed, but this procedure frequently delays the development of the clone. Leaf-petiole grafts can be made at any time during the year, for stolons are not necessary. The only requirement is that leaves of the proper age and size be available. Use of leaf-petiole grafts speeds indexing as virus symptoms usually appear sooner in indicator plants which have been leaf-petiole-grafted than in those which have been stolon-grafted. Weak plants can be indexed; plants of cultivated varieties are sometimes so weakened from one cause or another that they will not put out runners; these can be grafted by the leaf-petiole graft technique just as soon as one or more leaves are of sufficient size. The systematic or random indexing of plants grown in isolation for certification can be accelerated. Leaves can be collected from the fields early in the season, placed in polyethylene-film bags and taken to a central location and grafted to indicator plants. When it is not convenient to make grafts immediately, the leaves can be kept in cold storage for a short time until the grafts can be made.

Preliminary tests carried on by the writer in 1957 indicated that excised leaf-petiole grafts were as efficient as stolon grafts in transmitting strawberry virus components generally present in the Pacific Northwest. To evaluate further the efficiency of the excised-leaf-petiole graft technique for transmitting strawberry viruses, the author conducted a series of parallel graft tests in 1958. The methods used and results obtained are reported herein.

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[1] Cooperative investigations by Crops Research Division, Agricultural Research Service, United States Department of Agriculture and Oregon Agricultural Experiment Station.

[2] Plant Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

Table 1. Comparative efficiency of using excised leaf-petiole and stolon grafts in indexing strawberries for viruses, 1958.

Series No.	Type of graft	Virus components combined	Number grafts Made	Number grafts Positive[a]	Number grafted plants showing symptoms caused by virus combinations	Relative severity of symptoms[b]	Incubation period (days) Range	Incubation period (days) Average
1	Stolon	Mottle + latent A	5	4	4	Moderate	26-37	30
	Excised leaf	Mottle + latent A	5	4	4	Severe	14-25	20
2	Stolon	Veinbanding + latent A	5	3	3	Moderate	14-35	24
	Excised leaf	Veinbanding + latent A	5	4	4	Severe	7-31	17
3	Stolon	Mottle + latent A	5	4	4	Moderate	15-46	27
	Excised leaf	Mottle + latent A	5	4	4	Moderate	13-36	18
4	Stolon	Mottle + latent A	4	3	3	Moderate	10-20	17
	Excised leaf	Mottle + latent A	4	4	4	Severe	7-14	9
5	Stolon	Veinbanding + latent C + mild crinkle	4	3	3	Moderate	10-25	21
	Excised leaf	Veinbanding + latent C + mild crinkle	4	4	4	Severe	10-30	16
6	Stolon	Mottle + latent C + mild crinkle	2	2	2	Moderate	16-28	22
	Excised leaf	Mottle + latent C + mild crinkle	2	2	2	Moderate	9-24	16

[a]Organic union as determined by physical examination and by runner severance method as described by Goheen (4).
[b]97 days after grafts made.

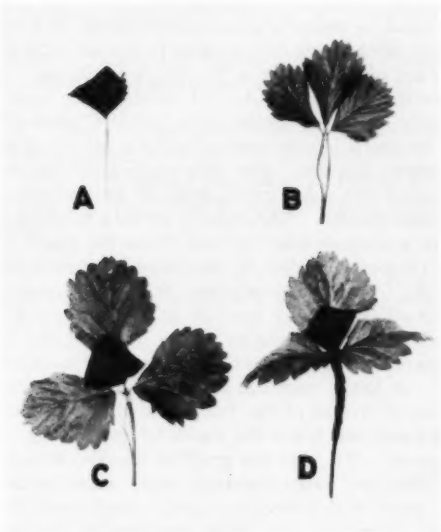

FIGURE 1. Steps in grafting excised leaves by a modification of the Bringhurst and Voth technique: A--prepared leaf scion from plant being indexed; B--stock leaf from indicator plant showing slit in petiole prior to insertion of scion; C--scion and stock in place; D--final step showing scion and stock tightly wrapped with latex tape and coated with water-asphalt emulsion (final step).

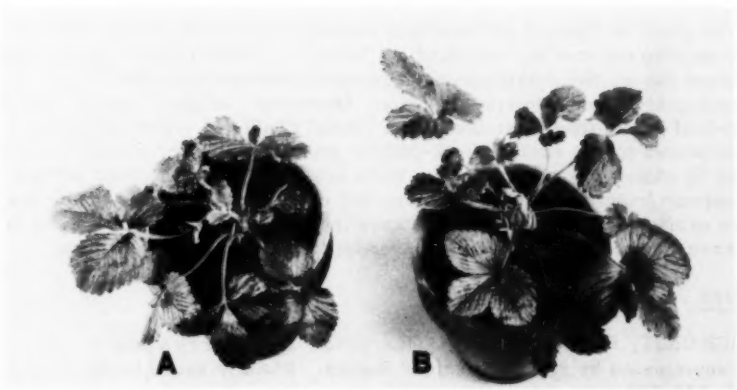

FIGURE 2. Virus symptoms in alpine hybrid vesca plants (F. vesca (East Malling) x F. vesca var. alpina) 97 days after grafting leaves infected, respectively, with mottle and latent A virus component: A--from an excised-leaf graft; B--from a stolon graft.

MATERIALS AND METHODS

The virus components used in these studies were mottle and veinbanding in a clone of an alpine hybrid Fragaria vesca (Frazier's UC-1 clone), latent A in F. vesca (East Malling clone), and latent C plus a mild strain of crinkle in a F. vesca seedling. These virus components were combined as follows: (a) mottle plus latent A, (b) veinbanding plus latent A, (c) veinbanding plus latent C plus mild crinkle, and (d) mottle plus latent C plus mild crinkle.

The grafts were made in pairs, each consisting of a stolon graft and an excised-leaf-petiole graft made from the same virus source. The approach-graft method of making stolon grafts was used in these investigations (8). A modification of Bringhurst and Voth's technique (1) was used in making the leaf-petiole grafts. The details of this modified technique are as follows: the lateral two leaflets from a mature excised leaf from the plant to be indexed are removed and about two-thirds of the terminal leaflet is cut away to reduce transpiration; this constitutes the scion petiole (Figure 1, A). The epidermis and part of the cortex from two sides of the scion are removed with a small triangular section of a sharp razor blade held in an "Exacto" holder so that the cut edges are at right angles to the plane of the leaf blade. The prepared scion is in the form of a tapered wedge, approximately 30 mm in length, and is kept in water while the stock is prepared. A long, vertical incision, about 32-35 mm in length, is then made along the suture of the petiole of a leaf of the indicator plant, starting just below the basal pair of leaflets. No leaflets are removed from the stock (Figure 1, B). The prepared scion is then inserted in the incision (Figure 1, C), and the graft is double-wrapped from the base upwards with strips (8 x 50 mm) of "Sealtex" latex bandage tape, a self-adhesive latex tape. The final step consists of coating the graft with a water-asphalt emulsion ("Tree Seal") to protect the latex tape from deterioration (Figure 1, D). It is imperative that the union be tightly wrapped; the latex tape can be tightly stretched as the graft is wrapped to bind the union securely. Two leaf-petiole grafts are made in each indicator plant to insure a successful graft. After being grafted, the plants are left in a moist chamber covered with polyethylene-film for about 10 days to reduce transpiration and facilitate healing. If the scions remain alive 1 month or longer, an organic union has taken place in practically all cases as indicated by a physical examination. While an organic union can occur in less time, all plants grafted with excised leaves that die in less than a month are regrafted.

RESULTS

The results given in Table 1 indicate that excised-leaf grafts are as efficient as stolon grafts in transmitting the mottle, veinbanding, latent A, latent C and mild crinkle virus components. In most cases, the combination virus symptoms were visible 5 to 10 days sooner with leaf-petiole grafts than with stolon grafts. Moreover, in some cases, a higher percentage of the excised-leaf grafts than of stolon grafts "took" (Table 1). The symptoms in the indicator plants produced by the excised-leaf-petiole grafts were more severe in most cases than those produced by stolon grafts though they were not essentially different in type (Figure 2).

It would appear from these investigations that excised-leaf-petiole grafts may be used in place of stolon grafts with reasonable assurance that if any of the viruses used in these experiments are present in the scion they will be transmitted to the indicator plant.

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CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE AND OREGON AGRICULTURAL EXPERIMENT STATION

NEW FACILITIES AND PROCEDURES USED FOR GROWING DISEASE-FREE STRAWBERRY PLANTS IN OREGON[1]

Norman D. Dobie, Edward K. Vaughan, P. W. Miller, G. F. Waldo[2]

The operation of the Oregon Strawberry Plant Propagation Center, established in 1954, was described in the Plant Disease Reporter in 1956 (1). Changes in facilities, propagation stocks, and procedures for testing for diseases since the original report was issued make the present report desirable.

In 1958, propagation stocks of 28 strawberry varieties and of selected seedlings apparently free from disease, insects and nematodes are available from the Oregon Strawberry Plant Propagation Center. Propagation stocks of 35 selected seedlings and 10 named varieties will be tested and increased in 1958 and will be available for distribution in the spring of 1959.

To insure protection for such large numbers of pest-free plants, a 70 x 30-foot insect-proof glass house was constructed in 1957 (Figure 1). This house is divided into a named-variety room, 25 x 30 feet; a selected-seedling room, 34 x 30 feet; and an isolation room, 9 x 30 feet. Each room is equipped with wooden benches on which flats placed on new bricks are maintained so that the progeny from individually potted mother plants can be trained into the elevated flats and held in place with sterilized wire staples (Figure 2).

The new Propagation Center is well aerated with screened ventilators on the top and sides as shown in Figure 1. Two evaporative coolers, one in each of the large rooms, maintain temperatures optimum for runner production during the summer. The isolation room contains a sorting bench with built-in soil bins, a large sink with a soil trap, a humidity chamber for holding indicator plants after grafting, and two benches for holding potted plants prior to entry into the variety or the selected-seedling room.

The methods of indexing for viruses, both visible and latent, have undergone several changes since the inception of the Oregon Strawberry Plant Propagation Center. A modification of the leaf-petiole graft technique, developed and described by Bringhurst and Voth (2), was used exclusively in indexing plants for viruses in 1957 and 1958. This modified method is described by Miller (3), who reports that under Oregon conditions leaf-petiole grafts are as effective in transmitting strawberry viruses as the stolon grafts and the virus symptoms appear earlier.

Each mother plant is tested by leaf-petiole grafts to each of three indicator plants: one Alpine hybrid Fragaria vesca known to be infected with mild mottle virus, one infected with vein-banding virus, and one F. vesca var. alpina known to be virus-free. When leaf-petiole grafts are used there is no physical contact between mother and indicator plants, thereby removing all possibilities of the transmission of a vesca-latent type virus from the indicator plant to mother and daughter plants of a clone under certification.

Verticillium wilt is increasing throughout Oregon and may become a limiting factor in strawberry production. Certified strawberry plants are the backbone of the industry. To insure that certified growers received plants free from this disease, at the second certification inspection two petioles are taken from each mother plant and plated on 2 percent water agar. Within 7 days all plates are examined for Verticillium and all plants found to be infected are immediately removed from the center. To further insure against possible spread of Verticillium wilt the mother plants are detached from the progeny and removed from the Center after the second runner plant is established.

In 1956-57, 22 varieties and selected seedlings passed all certification inspections and 2952 runner plants were made available for sale to propagators or for distribution to cooperating individuals and institutions. In 1957-58, 28 varieties and selected seedlings passed all certification inspections and 2670 runner plants were dug and are now available for sale to propagators or for distribution to cooperating individuals and institutions.

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[1]Approved for publication by the Director of the Oregon Agricultural Experiment Station and by the Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

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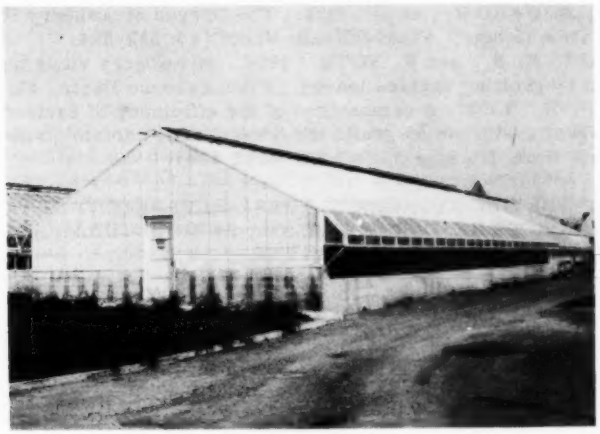

FIGURE 1. General exterior view of the new 70 x 30-foot Oregon Strawberry Plant Propagation Center, showing side ventilators screened with 20 x 20 mesh plastic screening.

FIGURE 2. Interior view of the Oregon Strawberry Plant Propagation Center, showing the variety and selected-seedling rooms. Individual flats show general method of propagating runner plants. Photograph by H. H. Milsap.

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CONTRIBUTION OF THE OREGON AGRICULTURAL EXPERIMENT STATION, EXTENSION SERVICE, AND THE CROPS RESEARCH DIVISION, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE.

TWO PROMISING COLD-TOLERANT INDEX HOSTS FOR THE PRUNE DWARF AND LINE PATTERN VIRUSES[1]

Paul R. Fridlund[2]

Abstract

In preliminary experiments, symptoms of the prune dwarf virosis on Krikon plum and the line pattern virosis on Ember plum appeared to be more severe than symptoms on the commonly accepted index hosts, Italian Prune and Shiro plum respectively. Both Krikon and Ember are extremely winter-hardy, whereas Italian Prune and Shiro plum are not. Consequently, the former two varieties can reasonably be substituted as index hosts for these virus diseases in areas where Italian Prune and Shiro plum cannot be grown.

Stone fruit virus research workers in the upper Midwest and similar extremely cold winter areas are hampered in their investigations by the cold tolerance limit of the commonly used stone fruit index hosts. For example, the varieties Italian Prune (Prunus domestica) and Shiro plum (Prunus salicina hybrid), which are used to detect the prune dwarf and line pattern viruses respectively, are not cold-tolerant enough in the field to survive in these areas. Therefore, there is a need to find cold-tolerant substitute index hosts.

With such varietal substitutes as an objective, several preliminary experiments were made to determine if suitable index hosts for the above two virus diseases could be found among the cold-tolerant varieties grown in such locations.

PRUNE DWARF VIRUS

In one comparison, four 1-year-old trees each of Krikon (Prunus insititia)[3] and of Italian Prune were bud inoculated in the fall with a prune dwarf virus culture. Three noninoculated trees of each were left as controls. The following spring all inoculated trees were badly stunted. All four inoculated Krikon trees and three of four Italian Prune trees had the typical strap-shaped leaf symptoms of prune dwarf. In general, the Krikon trees had a much greater percentage of shoots with symptoms than did the Italian Prune trees. The symptoms on individual leaves of Krikon were also much more severe. During the second growing season the contrast between the two varieties was even more striking. Krikon was again very severely stunted, in comparison with Italian Prune which was only moderately stunted (Fig. 1). Although all inoculated trees had symptoms, every shoot and nearly every leaf on Krikon had symptoms while only about 50 percent of the Italian Prune shoots had symptoms. Apparently the virus was completely systemic in Krikon but not in Italian Prune. Measurements of leaves with symptoms and of normal leaves of the two varieties were made. In Krikon the length of leaves with symptoms averaged 60 percent of the length of healthy leaves and the width averaged 30 percent. In Italian Prune the length of leaves with symptoms averaged 91 percent of the length of healthy leaves and the width averaged 52 percent (Fig. 2).

[1]Scientific Paper No. 1760, Washington Agricultural Experiment Stations, Pullman, Washington. This work was conducted under Project No. 1262 and was supported by Interregional Research Project IR-2.

[2]Associate Plant Pathologist, Department of Plant Pathology, State College of Washington, Irrigation Experiment Station, Prosser, Washington.

[3]According to Mr. Bj. Loss of the Lake City Nurseries, Lake City, Minnesota, Krikon was introduced from Sweden into the Jewel Nursery, Lake City, about 1905. There is no doubt of its winter hardiness, as mimeographed information received by the author from the Department of Horticulture, University of Minnesota, has shown Krikon to be one of the three hardiest prune type plums ever tested there. Under controlled tests it survived temperatures of minus 50° F and had no damage at minus 40° F.

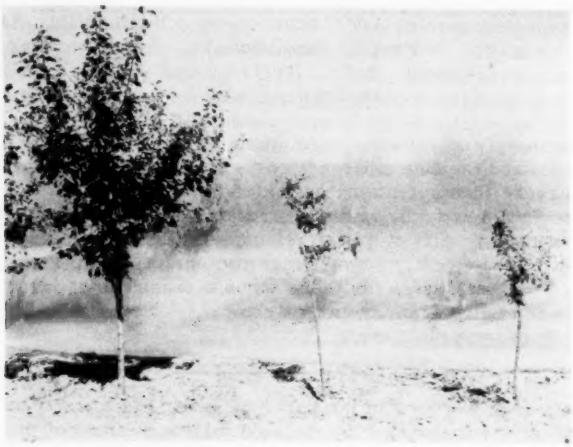

FIGURE 1. General stunting in Krikon caused by the prune dwarf virus. Healthy tree on left.

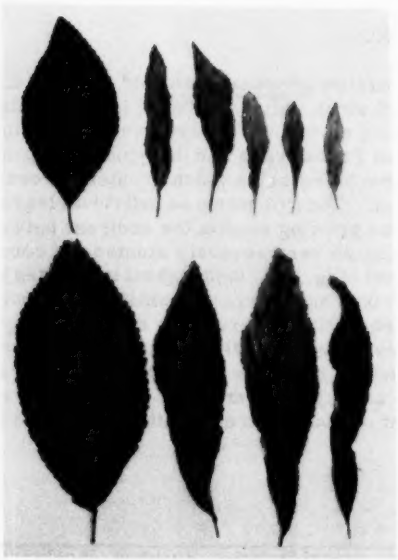

FIGURE 2. Typical strap-shaped leaves caused by the prune dwarf virus on Krikon (top) and Italian Prune (bottom). Healthy leaves at left.

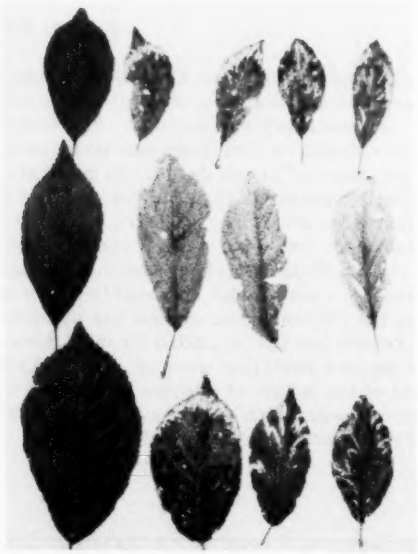

FIGURE 3. Typical line pattern symptoms on Shiro (top), Ember (center) and LaCrescent (bottom). Healthy leaves at left.

A further experiment compared symptoms in the two varieties, using a rapid symptom-expressing technique. In this experiment, peach rootstocks were double-budded in the fall with both healthy indicator buds and inoculum buds. In this technique, which has been used occasionally, it is assumed that the prune dwarf virus will spread from the inoculum bud to the rootstock and in turn to the healthy indicator bud. Thus, when the indicator buds commence to grow the following spring, symptoms will appear almost immediately on the young shoots. Several sources of inoculum were used. All the Italian Prune indicator buds grew and had good prune dwarf symptoms. Only a few Krikon buds grew, but these had the very severe leaf symptoms as produced in the previous experiment. Since most of the Krikon buds on inoculated rootstocks were killed whereas all buds on noninoculated rootstocks grew, it appears that this variety is extremely sensitive to the prune dwarf virus or possibly the contaminating necrotic ring spot virus or both. In any case, it appears that Krikon is too sensitive to use for this rapid technique on peach rootstocks.

The results of these experiments and other information available indicate that Krikon is acceptable as an index host for the prune dwarf virus in extremely cold areas where Italian Prune cannot be grown. The results of these tests also indicate that nursery trees of Krikon may be superior to Italian Prune as an index host for this virus disease.

LINE PATTERN VIRUS

In one comparison three 1-year-old nursery trees each of Shiro, Ember, LaCrescent, and Underwood plums were bud inoculated in the fall with a line pattern virus culture which was free from a contaminating ring spot virus. The latter three varieties were selected for testing because they are cold-tolerant hybrids of Shiro plum and Prunus americana. (Ember = Shiro x So. Dak. 33; LaCrescent = Shiro x Howard Yellow; Underwood = Shiro x Wyant.) Five noninoculated trees of each were left as controls.

During the spring following inoculation, three Shiro trees, three Ember trees, and one LaCrescent tree had typical line pattern symptoms. Little difference in symptom intensity was noted among these varieties. During the second growing season after inoculation, all inoculated trees of Shiro, Ember, and LaCrescent had symptoms, but Underwood had none. Although all three varieties had severe symptoms, the symptom color intensity in Ember was more severe than in the others. The symptoms in Shiro and Ember were completely systemic and appeared in every branch, but in no case were symptoms completely systemic in LaCrescent. In Shiro and LaCrescent the color patterns were primarily of the oak leaf type, whereas in Ember they were predominantly the golden net vein-banding type (Fig. 3).

Further experimentation on the differences between the four varieties was made on peach rootstocks. The method was similar to that previously described, using a rapid technique. The following spring all the buds grew, and all the inoculated plants, including the Underwood, had symptoms. Arbitrary visual classification rated the Ember symptoms as severe, Shiro and LaCrescent as moderate, and Underwood as mild. The same results were also obtained in a similar rapid technique experiment using P. americana as rootstocks.

On the basis of these experiments, Ember plum appears to be a satisfactory index host for the line pattern virus in cold climates where Shiro plum cannot be grown. As this variety has been widely distributed throughout the colder parts of the Upper Midwest, it must carry a cold tolerance sufficient for survival almost anywhere in the United States. From these tests this variety also appears to express more severe symptoms of the line pattern virus than the commonly used index host, Shiro plum.

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OBSERVATIONS ON DISTRIBUTION OF CACHEXIA OF CITRUS IN CALIFORNIA AND ARIZONA

E. C. Calavan[1], J. B. Carpenter[2], and L. G. Weathers[3]

Cachexia, a virus disease of citrus, was first described from Florida in Orlando tangelo (Citrus paradisi x C. reticulata) by Childs (1) in 1950. Olson (5) reported cachexia in Texas in 1952. Florida and Texas workers (2, 3, 5, 6) soon demonstrated that a large number of varieties and hybrids of mandarin orange (C. reticulata Blanco) express symptoms of cachexia. Additional work led to the suggestion by Childs (2) that cachexia is identical with xyloporosis, as described by Reichert and Perlberger (8) in 1934. In 1957, cachexia was listed as a synonym of xyloporosis (4). However, the authors prefer to use the name cachexia for the disease syndrome found on certain mandarins and tangelos discussed in this paper because current experiments have not yet shown whether cachexia as observed in California is identical with or distinct from xyloporosis.

At the time cachexia symptoms were first described by Childs (1) very few Orlando tangelo trees were growing in California, and those available for examination appeared to be healthy. After workers in Florida and Texas (2, 3, 5, 6) showed that numerous other citrus species and varieties are susceptible to cachexia, many mandarins and tangelos in southern California were examined for symptoms.

The first cachexia-like symptoms in California were found in early 1954 in trunks of two Willow Leaf mandarin trees, 5 years old, growing in a variety planting at Indio. These trees had vein chlorosis in the leaves, stunted growth, gum deposits in the phloem and in rings of the xylem, and pitting on the cambial faces of both the wood and the bark. The source of infection for the Willow Leaf mandarin trees was not determined; the trees were destroyed.

In January 1955, two young, severely diseased Wekiwa tangelo trees with striking symptoms of cachexia were found in a commercial planting, also near Indio. The owner recalled that the scions had been propagated from a 25-year-old Wekiwa tree onto sour orange (C. aurantium L.) shoots growing from severed roots of the rootstock under a large old-line Marsh grapefruit (C. paradisi Macfad.) tree. The parent Wekiwa tree was located nearby and found to be vigorous and free of cachexia symptoms. It appeared, therefore, that the young Wekiwa tangelo trees acquired cachexia from their sour orange rootstocks, which were infected from the old-line Marsh grapefruit.

Previously, buds of the diseased Wekiwa trees had been grafted onto Rough lemon (C. jambhiri Lush.)[4] in a commercial nursery. At 2 years of age the trunks of all the trees had severe symptoms of cachexia above the bud union (Figure 1). All these diseased Wekiwa tangelo trees were removed.

Since 1955 cachexia has been found in several locations in southern California. This disease is widely distributed in plantings of Clementine mandarin (Algerian tangerine) trees in the Coachella and Imperial Valleys although it is estimated that cachexia symptoms have appeared on less than 1 percent of the trees. Cachexia was identified in 1956 in a Wekiwa tree near El Centro in the Imperial Valley.

Cachexia has been observed repeatedly in Arizona since 1954 in trees of Orlando, Seminole, and Sunshine varieties of tangelo in variety plantings[5]. The budwood for these diseased trees had been obtained from scion trees of undetermined virus content and had been top-worked onto old-line grapefruit trees. Many old-line grapefruit trees of Marsh and other varieties carry the cachexia virus in Florida (3) and in Texas (7). Presumably a similar situation may exist in trees of the same varieties in Arizona and California.

Experiments on the transmissibility of cachexia were begun in June 1954. Symptoms of cachexia were reproduced within 3 years after graft-inoculation of (a) Sunshine tangelo seedlings with buds from one of the originally observed Willow Leaf mandarin trees, and (b) seed-

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[3]Assistant Plant Pathologist, University of California Citrus Experiment Station.
[4]See Hodgson, R. W. 1956. Twenty-five years of citrus introduction at U. C. L. A. (Part III). Citrus Leaves 36(8): 18, 32 and Lushington, A. W. 1910. The genus Citrus. Indian Forester 36: 323-353.
[5]Most of the Arizona observations in 1954 were made in conjunction with R. H. Hilgeman and R. B. Streets of the University of Arizona and J. M. Wallace of the University of California.

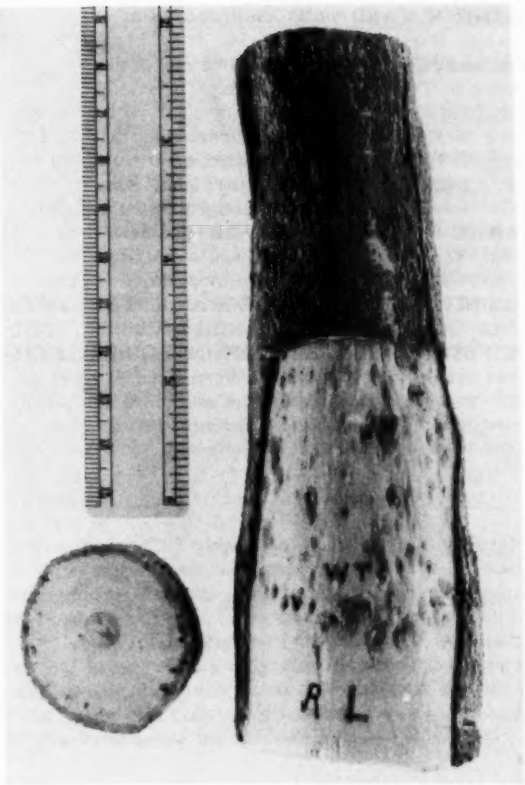

FIGURE 1. Cachexia symptoms in cross-section (left) of 2-year-old trunk of Wekiwa tangelo, and on surface of same trunk (WT) from which a portion of the bark has been removed. Grooves in Rough lemon rootstock (RL) are scratches.

ling-line Chao Chon Tien (Tien Chieh) mandarin trees with buds from one of the previously mentioned Wekiwa nursery trees. All control plants have remained symptomless. The results of inoculations from various sources of cachexia-affected trees in California into a wide range of other indicator plants cannot yet be evaluated.

There has been no official attempt to restrict the movement of cachexia (or of xyloporosis) in California despite the probability that large numbers of infected grapefruit and other usually symptomless carriers are involved in commercial citrus propagation. A program for the establishment and maintenance of virus-free foundation stock is now in the process of development in cooperation with the California State Department of Agriculture. Until this program can be fully implemented, it is recommended that nurserymen exercise maximum precautions in selecting parent tree sources for the propagation of citrus varieties which express cachexia or xyloporosis.

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EFFECT OF HYDROGENATED FISH OILS ON CITRUS-TREE DESTROYING NEMATODES[1]

George Renninger, John Coffey, and Boris Sokoloff[2]

Summary

A water-soluble hydrogenated fish oil preparation, labeled FOAH, was tested on Radopholus similis, the burrowing nematode which causes spreading decline of citrus trees. A pilot plant, consisting of 12 cylinders each 45 inches tall and 6 inches in diameter, filled with soil to a depth of 42 inches, was used for the trials. The number of nematodes in infected roots placed on the bottom of the cylinders was reduced to 5.1 percent as compared with unsprayed controls, by spraying the soil surface with 600 ml of a 1.5 percent concentration of FOAH, on two consecutive days. FOAH at 1.5 percent has shown no toxic effect on orange seedlings. The theory is suggested that the water-soluble hydrogenated fish oil preparation interfered with respiration and oxidation processes in the nematodes, thus suffocating them.

The burrowing nematode, Radopholus similis (Cobb) Thorne, the cause of spreading decline of orange trees, is responsible for great damage to the citrus industry in Florida. Other citrus-tree destroying nematodes, like Tylenchulus semipenetrans, might be considered as less harmful in this respect. Living 6 to 12 feet below the surface, Radopholus similis burrows into the feeder roots of trees and so far has resisted any attempt made to control it by chemical means. The only effective method used at present for fighting spreading decline is by destroying the trees in an infested area and by fumigating the soil afterward.

In the present study, an attempt was made to control burrowing nematodes by spraying the soil with hydrogenated fish oils.

FATTY ACIDS AS NEMATOCIDALS

It has been known for a number of years that certain fatty acids such as undecylenic acid possess nematocidal activity when applied in vitro to Xiphinema americanum and to eggs of the root-knot nematode, Meloidogyne incognita. This observation, made by Kofoid and White in 1919, was confirmed more recently by Chitwood (1). The method of testing consisted in immersing nematodes in an emulsified water solution of undecylenic acid for 24 hours at 75° F and then placing them around the roots of tomato plants. The controls, not treated with fatty acid, were immersed in water for the same period of time and also placed around the roots of tomato plants. The number of infested plants, treated and control, were compared and the index of effectiveness of the compound thus measured. Undecylenic acid, although effective in vitro, was found ineffective when used as spray on the infested area, according to Smith and Taylor (4). Furthermore, this fatty acid was toxic to the plants which were sprayed with it. All treated tomato plants infested with root knot were killed by undecylenic acid.

Tarjan and Cheo (6) conducted an extensive investigation of the nematocidal value of fatty acids. They tested a number of saturated and unsaturated fatty acids in vitro on the nematodes Panagrellus redivivus, Heterodera tabacum, Pratylenchus penetrans, and others, with encouraging results. Their attempts to disinfest nematode-contaminated soil were less satisfactory. The fatty acids were added to canisters of soil in which roots containing numerous egg masses of the root-knot nematode, Meloidogyne incognita, had been mixed. Results indicated that caprylic and pelargonic acids were effective in achieving complete control of the

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[1]Presented at the Annual Meeting of the Florida State Horticultural Society, Citrus Section, October 31, 1957, Miami, Florida; and at the Annual Meeting of the Florida Academy of Sciences, Stetson University, December 5, 1957.

Aided by the Florida State Plant Board and the Ford Ellis Fund, New York, New York.

[2]Southern Bio-Research Institute, Florida Southern College, Lakeland, Florida.

nematode only when a 4 percent acid preparation was used. When caprylic and pelargonic acid preparations were applied at rates from 0.1 to 2.0 g per square foot to the potted soil in which violets parasitized by pin nematodes, Paratylenchus sp., were growing, no significant reduction of nematodes in the soil was observed. Referring to their tests in vitro, these authors concluded: "Certain fatty acids in the intermediate carbon numbered group have been found to possess exceptional nematocidal activity." (p. 38)

From this brief review of the work conducted on the nematocidal activity of certain fatty acids one may see that these compounds were detrimental to nematodes when applied in vitro, but showed very little, if any, effect in the tests in vivo.

THE BURROWING NEMATODE

Radopholus similis, which attacks the roots of citrus trees, has a strong sexual dimorphism. The phasmids are distinct in both sexes, being situated at about one-third tail length behind anus. The tail is conoid, tapering to a blunt end. The spear is strong, with large basal knobs. The oocytes are mostly in single file, except for a short zone of multiplication. The eggs are about twice as long as the body width, with a thick cuticle.

Numerous chemicals kill the burrowing nematode within seconds or minutes when the worms are immersed in a solution in a watch glass. Yet the complete control of the burrowing nematodes under natural conditions of their existence meets with obstacles which have not been overcome so far. Many factors are involved in this problem: the facts that the nematodes live 6 to 12 feet below the soil surface, that the egg stage is very resistant to any unfavorable environment, and that because of their burrowing habits they are partially protected by plant roots. Under these circumstances, any attempt that achieves even partial control of burrowing nematodes may deserve, we feel, some attention on the part of nematologists.

HYDROGENATED FISH OILS AS NEMATOCIDALS

During the years 1952-56, several papers by Tomiyasu et al. (7-11) and Toyomizu (12), of Kyushu University, Japan, appeared regarding the antibiotic, specifically the antifungal, properties of fish oils. Following this discovery, our Institute initiated an investigation along the same lines under contract with the United States Department of the Interior Fish and Wildlife Service.

Fish oils are a rich source of unsaturated and saturated fatty acids. Various fish oils, from menhaden, pilchard, and other fishes, and their fatty acid fractions were tested on fungi, both in culture and in the field. We confirmed the findings of the Japanese scientists and stressed the value of fish oils as mild fungicides (5). In the course of this investigation, however, it became clear to us that the water-insolubility of the fatty acids was an adverse factor which interfered with the biological activity of these acids. Accordingly, an attempt was made by us to transform fish oils into a water-soluble material. This was accomplished by a procedure previously described by us (2) by means of an acetone fractionation. The water-soluble fish oils, labeled FOA, possessed a much higher antifungal activity than the water-insoluble fish oils, but the activity was still moderate. It was decided to hydrogenate the fish oils, which was accomplished by submitting them first to the action of hydrogen and platinum black catalyst. After hydrogenation, a water-soluble material was obtained and combined chemically with hydride salts, which have four molecules of hydrogen. As the end results of this chemical procedure, highly hydrogenated fish oils were obtained, labeled FOAH. It was this material, FOAH, which was tested by us on the citrus burrowing nematode.

METHOD OF TESTING

The testing was conducted in what one may call a pilot testing plant.

Pilot Plant

The plant consisted of 12 cylinders, 44 inches tall and 6 inches in diameter, which were filled with soil up to 42 inches high (Fig. 1). Eight cylinders served for testing the compound and four cylinders were used for control. Preliminary tests were conducted with cylinders filled with soil up to 6 inches. Nematode-infested roots were placed on the bottom of the cylinders. The bottoms were perforated. The roots were covered with 6 inches of soil taken from the same area as the roots. The solution of FOAH was sprayed directly on the surface

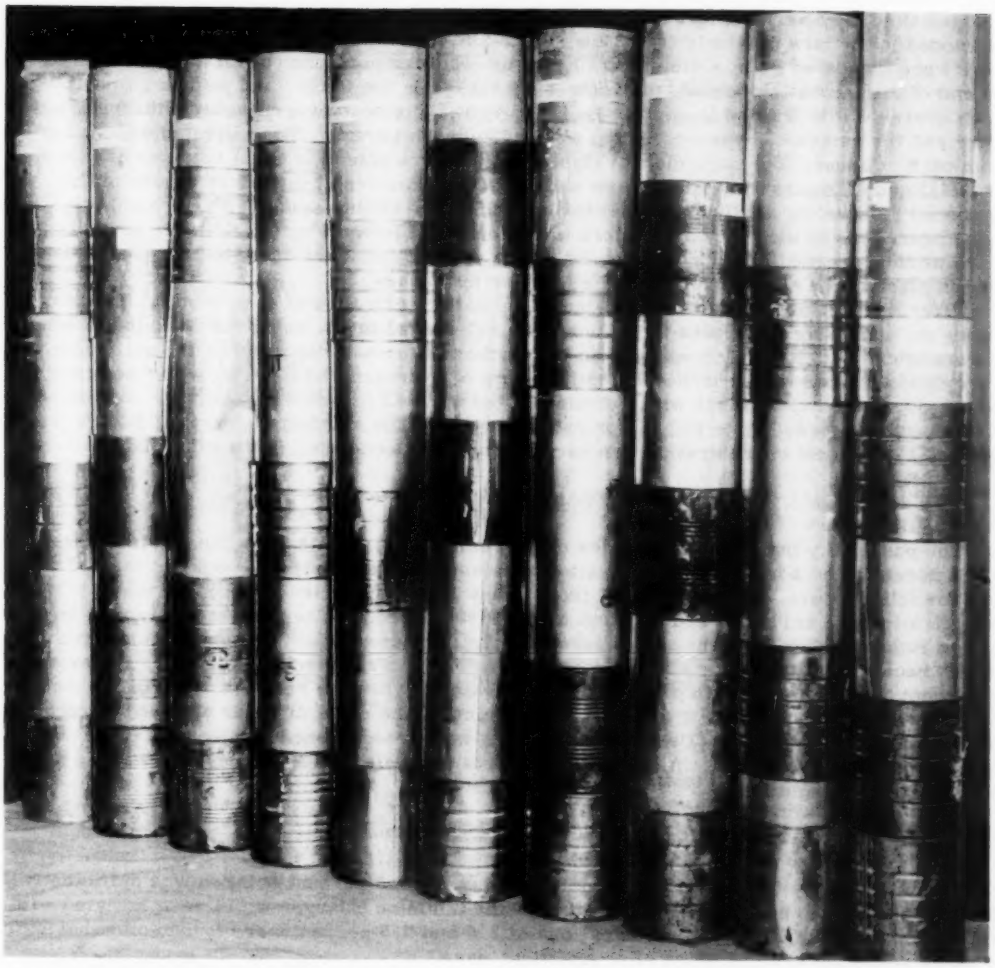

FIGURE 1. The pilot plant for testing effect of hydrogenated fish oil preparation on Radopholus similis. Cylinders are 44 inches tall, filled with soil up to 42 inches, and 6 inches in diameter. Infested roots are placed on the bottom of the cylinder. The preparation is sprayed on the soil surface. Four cylinders serve as control and eight are treated. Originally only ten cylinders were used as shown in the photograph, but currently two more have been added.

of the soil and allowed to leach through to the roots. After 24 hours, a second spraying of FOAH was applied. The roots were allowed to remain in the soil for an additional 48 hours at which time they were removed, washed and placed in separate labeled jars. Then water was added to the jars to nearly cover the roots. Lids were placed loosely on the jars and the roots were incubated in the water for 72 hours at room temperature, about 25° to 26° C. At the end of the incubation period, the roots were shaken in the water, and poured into a 100-mesh screen which drained into a 325-mesh screen. The roots were flushed with fresh tap water and the nematodes were collected on the 325-mesh screen. The collected nematodes from each cylinder, four controls and eight treated, were placed in equal volumes of water and 10 aliquot samples were taken from each for determination of the effectiveness of the compound by counting all living nematodes in each of 120 aliquot samples. The numbers of living nematodes in the treated cylinders were compared with the numbers in the controls, which were processed in the same manner as the treated cylinders but with plain water being used in place of the compound during the leaching processes.

After the preliminary tests with 6-inch deep soil, which showed good results, the actual testing on burrowing nematodes in 42 inches of soil was initiated, using the described method. The amount of FOAH solution sprayed on the surface of the soil depended on the soil depth. For cylinders filled with 6-inch-deep soil, 100 ml of hydrogenated fish oil, water solution, was used. In the experiments with cylinders filled up to 42 inches with soil, the amount of solution was increased up to 600 ml for each spraying. The standard solution of FOAH, water-soluble, 1.5 percent concentration was used in our trials conducted in the pilot plant.

Staining of Roots

The possibility that some nematodes might remain in the roots after the treatment with FOAH necessitated a histologic examination of infested roots. An aceto-osmium method was used for this purpose. The roots were fixed in a solution composed of 13 ml formalin (40 percent), 5 ml acetic acid, and 200 ml ethyl alcohol (50 percent). The roots were washed for 1 hour in running water, bleached in 40 percent hydrogen peroxide at 32° C until the darkened tissues became lighter, and placed in a solution containing 2 parts of osmic acid, 10 parts of 10 percent acetic acid, and 16 parts of distilled water. When the reaction of peroxide decomposition was well under way, it was arrested by rinsing the roots in water or in a 1 percent solution of sodium bisulfite. Dehydration of roots was accomplished by means of 95 percent ethyl alcohol, changed twice. At the end, the roots were cleared by immersing them in a methyl salicylate solution.

RESULTS

The preliminary tests with FOAH indicated that the 1.5 percent solution was sufficiently effective against the nematodes. Accordingly, the trials on a larger scale were initiated with this concentration of FOAH. Concentrations of 2.0 and 2.5 percent were found somewhat toxic to citrus seedlings and therefore of no practical use.

In Tables 1 and 2, the results of these trials are briefly summarized. Table 1 gives the data on the preliminary trials with cylinders filled with 6-inch-deep soil; Table 2 on tests with 42-inch-deep soil. In both instances, the figures in the Tables represent the average number of nematodes found alive in the control and treated cylinders; 160 aliquot samples for control, and 320 aliquot samples for treatments with FOAH, in Table 1; 480 control aliquot samples and 960 treated aliquot samples in Table 2.

The number of nematodes remaining alive after a 2-day consecutive spraying of the surface of soil 6 inches deep with 100 ml of 1.5 percent solution of FOAH was 15.3. The average number of nematodes alive in the control jars was 156.2; that is, about 10 percent of nematodes escaped destruction by the spraying.

The number of nematodes alive after a 2-day consecutive spraying of the surface of soil forty-two inches deep with 600 ml of 1.5 percent FOAH solution was 6.8, against the average number 132.4 for the control. About 95 percent of the nematodes originally located 42 inches below the soil surface were destroyed by spraying the surface with FOAH. Apparently the larger amounts of the spray solution favored better results. The osmium staining of the roots after they were washed revealed no nematodes that had burrowed into the roots.

Table 1. The effect of hydrogenated fish oil (FOAH) on burrowing nematodes, in cylinders filled with 6-inch-deep soil.

Treatment	Number cylinders	Total number aliquot samples	Average number nematodes surviving
Control -- sprayed with 100 ml water for 2 consecutive days	16	160	156.2
Treated -- sprayed with 100 ml FOAH for 2 consecutive days	32	320	15.3
Average percentage survival in treated group as compared with control			10.2

Table 2. The effect of hydrogenated fish oil (FOAH) on burrowing nematodes, in cylinders filled with 42-inch-deep soil.

Treatment	Number cylinders	Total number aliquot samples	Average number nematodes surviving
Control -- sprayed with 100 ml water for 2 consecutive days	48	480	132.4
Treated -- sprayed with 100 ml FOAH for 2 consecutive days	96	960	6.8
Average percentage survival in treated group as compared with control			5.1

FIGURE 2. The pumping sprayer which permits spraying infested roots and soil 12 to 15 feet below the soil surface.

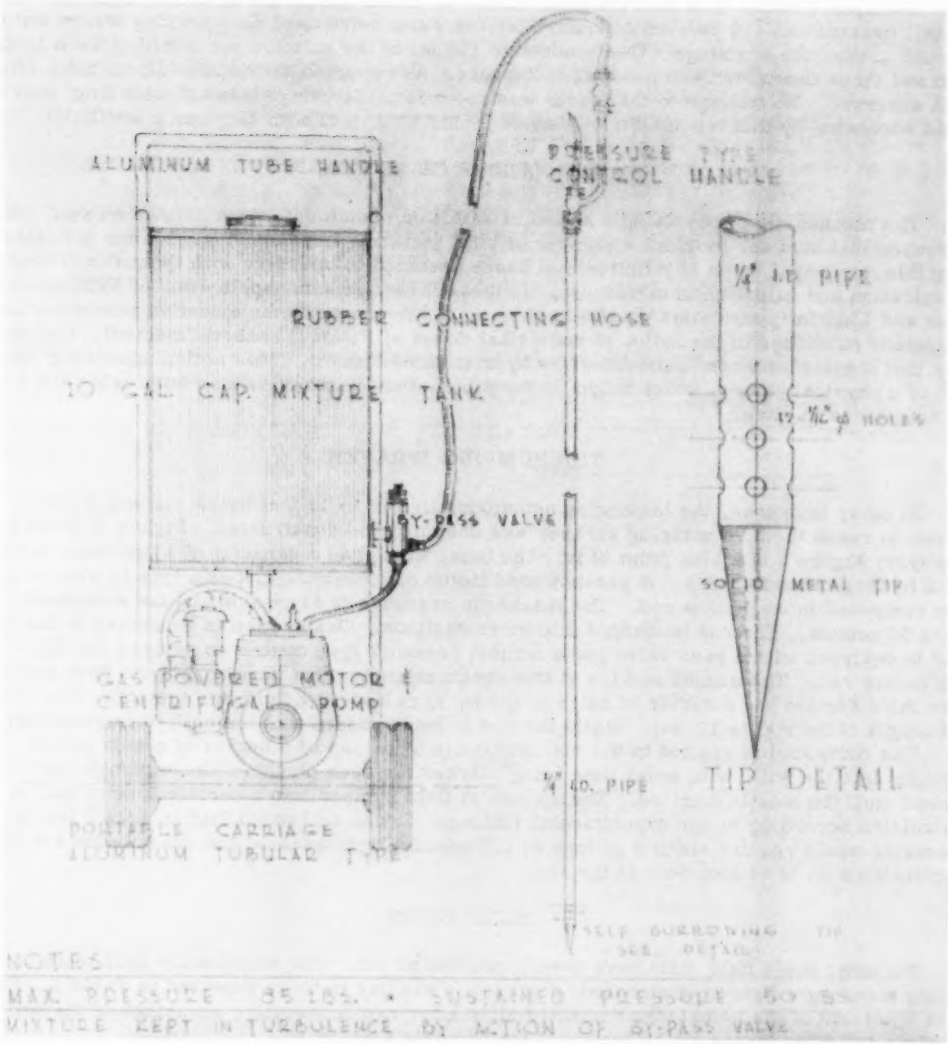

FIGURE 3. The blue print of the pumping sprayer.

BIO-ASSAYS

The hydrogenated fish oil FOAH was tested on citrus seedlings of various ages and sizes. Both 1 percent and 1.5 percent concentrations in water were used for spraying leaves and the ground around the seedlings. One hundred to 150 ml of the solution per seedling were applied two and three times, with an interval of 2 weeks. As reported previously (3), no toxic effect was observed. No damage to the leaves was recorded. Seedlings infected with fungi benefited somewhat by this treatment, evidenced by faster growth with brighter green color.

THE NATURE OF ACTION

The mechanism of physiologic action of FOAH on nematodes is not defined as yet. The cytochemical studies, in which a number of vital stainings were used, gave some indication that this compound, even in infinitesimal doses, seemed to interfere with the processes of respiration and oxidation in nematodes. In these investigations, application of Lithium-trypan blue and Lithium-pyrrol blue supplied evidence of a decrease in the oxidative processes in a nematode submitted to the action of non-lethal doses of FOAH (Brachet's method). One may say that nematodes were "suffocated" by hydrogenated fish oil. This action apparently was not of a physical nature, which might be suspected when water-insoluble fatty acids are applied to nematodes in vitro.

THE PUMPING SPRAYER

In many instances, the burrowing nematodes live 10 to 12 feet below the soil surface. In order to reach them, a pumping sprayer was designed and constructed. Figure 2 shows the sprayer; Figure 3 is a blue print of it. The tank, which has a capacity of 10 gallons, is filled with hydrogenated fish oils. A gas-powered motor of a centrifugal-pump type is used to force the compound into a hollow rod. The maximum pressure is 85 pounds and the sustained pressure 50 pounds. The rod is divided into three sections. One section is connected to the tank and is equipped with a pass valve and a manual pressure type control to release the fluid into the hollow rod. The second section is merely an extension that screws into the first section. The third section has a series of holes in the tip to release the fluid into the soil. The overall length of the rod is 13 feet. While the rod is being pushed into the soil, it is rotated slowly.

The compound is applied to the soil uniformly by means of a series of evenly placed plunges into the soil, with equal time being allowed for each plunge. These plunges are continued until the tank is emptied. The amount of fluid pumped into a certain area of soil is calculated according to our experimental findings. It was estimated that an area 5 feet in diameter would require about 8 gallons of 1.5 percent hydrogenated fish oil solution for two applications up to 14 feet deep in the soil.

FIELD TESTS

No large scale field tests have been conducted as yet. The small scale field tests on 12 young trees gave figures of nematode destruction similar to those reported in Table 2. From 5 to 8 percent of the nematodes remained alive after two consecutive sprayings of the soil surface and after treatment by means of the pumping sprayer.

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POST-HARVEST TREATMENT TO CONTROL STRAWBERRY FRUIT ROT[1,2]

R. F. Becker, R. N. Goodman, and H. S. Goldberg[3]

Several workers have successfully reduced the amount of Botrytis fruit rot of strawberry under field conditions. However, comparatively little has been done to prevent post-harvest decay of mature berries caused by the Botrytis and Rhizopus fruit rot organisms. Di Marco and Davis (1) reported that the antibiotic nystatin substantially reduced the amount of post-harvest decay when added to the cooling water of a hydrocooler. In these tests captan was less effective than the antibiotic. Thompson (2) indicated that 0.5 to 1.0 percent solutions of dehydroacetic acid gave almost complete control of both Rhizopus and Botrytis fruit rots, but that captan, cycloheximide, and sodium orthophenylphenate were only slightly effective.

METHODS

During the peak of the harvest period, ripe berries of the varieties Dixieland and Blakemore were picked and stored overnight at 45° F. The following morning, the fruit was spread upon kraft paper and sprayed with a concentrated spore-mycelium suspension of Botrytis cinerea (NRRL 1648) previously grown on strawberry fruit. The intent was to simulate conditions of a heavy natural field inoculation. After a 4-hour incubation period, 2 quarts of each variety were placed in wire baskets and immersed for 1 minute in 100 ppm solutions of the antifungal antibiotics cycloheximide, oligomycin, rimocidin, anisomycin, nystatin, griseofulvin, thiolutin, and P189 (code number of Chas. Pfizer Co.). Berries were also dipped in a 1000 ppm solution of the fungicide captan. To assess the effect of the dipping solution per se, two controls were employed, a dry control and a water control. The water-control berries were immersed in water for 1 minute.

The fruit from all treatments, after drying for 2 hours, was sprayed with a spore suspension of Rhizopus stolonifer (R. nigricans), (NRRL 1477), air-dried, packed into quart berry boxes and stored at 21° C.

Table 1. Percentage of Dixieland and Blakemore strawberry fruit in each of four decay categories 48 hours after treatment.

Treatment*	Dixieland				Blakemore			
	No decay	Slight	Moderate	Heavy	No decay	Slight	Moderate	Heavy
Dry control	76	20	2	2	61	34	5	1
Water control	36	55	9	0	52	37	10	2
Captan	64	33	2	2	58	40	2	0
Anisomycin	35	60	4	0	42	46	8	4
Cycloheximide	89	11	0	0	67	30	2	0
Griseofulvin	47	48	5	0	46	45	8	1
Nystatin	73	25	2	0	54	43	3	0
Oligomycin	69	29	2	0	71	26	3	0
P 189	35	52	13	0	20	61	18	1
Rimocidin	47	47	5	2	47	48	4	1
Thiolutin	59	41	0	0	43	52	6	0

*Antibiotics used at concentrations of 100 ppm; captan used at 1000 ppm.

[1]This study was conducted with funds from United States Public Health Service Grant RG 4407-C, National Institutes of Health, Bethesda, Maryland.
[2]Journal Series Paper No. 1893. Approved by the Director of the Missouri Agricultural Experiment Station.
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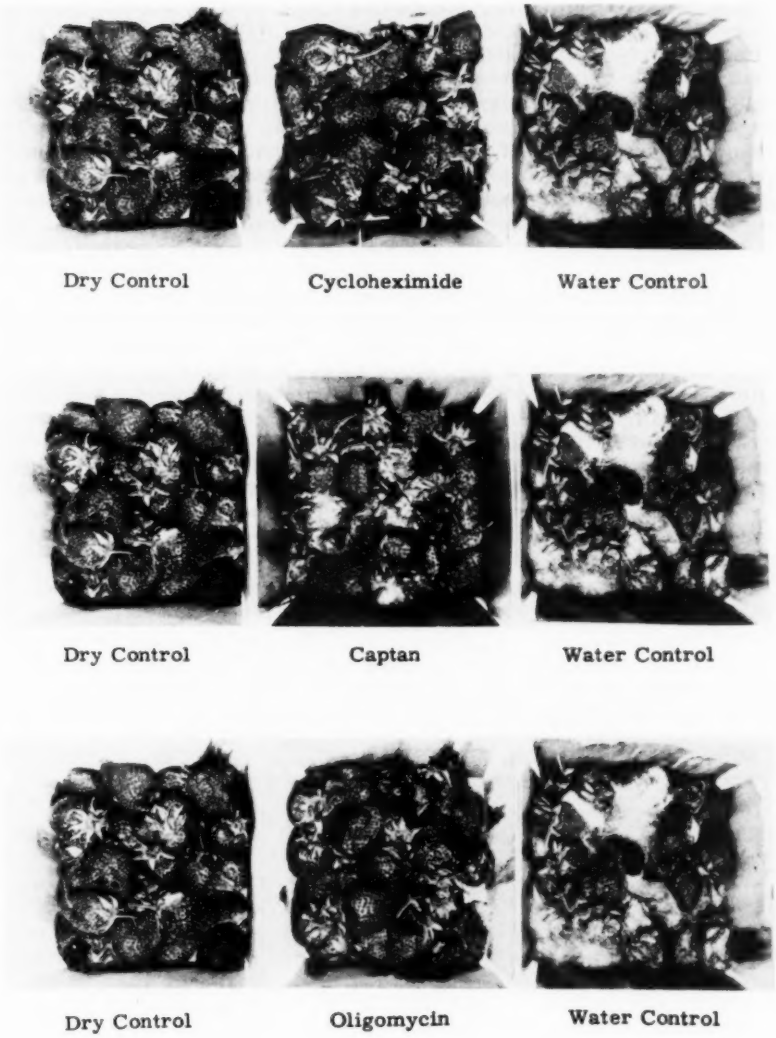

FIGURE 1. Condition after storage for 60 hours, of Dixieland strawberries treated with cycloheximide, captan, and oligomycin, respectively, as compared with berries stored dry (dry-control treatment) and with berries dipped in water before storage (water-control treatment).

Half of the fruit from each treatment was examined for decay development after 48 hours and the remainder was observed 24 hours later. Each berry was inspected and placed into one of four groups, based on the amount of rot present: none, slight, moderate, or heavy. Isolations were made from infected fruit to determine which fungus species was predominant.

RESULTS

Data presented in Table 1 indicate that with the Blakemore variety, oligomycin- and cycloheximide-treated fruit evidenced less decay after 48 hours than did fruit from all other chemical treatments as well as from the dry control. Captan and several of the antibiotic treatments suppressed decay to some extent when compared with the water control. With the variety Dixieland, cycloheximide was superior to all other treatments, including the dry control. Captan and all but two antibiotics limited decay more effectively than did the water control.

After 72 hours of storage, the dry-control berries of both varieties manifested the least decay of any treatment. Cycloheximide and oligomycin were more effective than other antibiotics and captan and were far superior to the water-control treatment.

Figure 1 shows berries from the two controls and the cycloheximide, oligomycin, and captan treatments.

The dry-control berries and those treated with cycloheximide and oligomycin were reasonably firm even after 72 hours, but fruit from all other treatments contained a high percentage of soft berries. In general, Dixieland berries tended to keep their shape, color and firmness better than did those of the variety Blakemore.

It was also noted that Rhizopus was the predominating fungus of the disease complex. Twenty-six of 35 random isolations from decayed fruit showed the presence of this organism.

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THE EFFECT OF CHLOROPHYLL ON THE PHYTOTOXICITY OF ACTI-DIONE[1] ON BEAN

Eugene M. Wilson[2] and Peter A. Ark[3]

Summary

Water soluble chlorophyll (Na-K chlorophyllin of the N. B. Cs.) reduced the phytotoxicity of Acti-dione to Pinto and Bountiful bean plants. At 1000 ppm chlorophyll and 10 ppm Acti-dione there was no apparent phytotoxicity or reduction in fungicidal activity. Chlorophyll did not appear to reduce the protective activity of Acti-dione against powdery mildew. The greater portion of the Acti-dione or Acti-dione-chlorophyll apparently remained on the surface of the plant, as there was no evidence of a systemic effect.

Chlorophyll (up to 1 percent) in aqueous solutions of 10 ppm Acti-dione only slightly reduced the inhibition of Saccharomyces cerevisiae.

INTRODUCTION

Phytotoxicity of Acti-dione is frequently a limiting factor in its use for the control of plant diseases. The concentration at which this antifungal antibiotic is phytotoxic varies from species to species. An excellent review of the papers dealing with the agricultural aspects of Acti-dione was presented by Ford, Klomparens, and Hamner[4].

The purpose of this study was to determine the influence of water soluble chlorophyll upon the margin between dosage levels of Acti-dione which gave control of powdery mildew of bean and those which injured the plant.

Table 1. The influence of increasing concentrations of chlorophyll in aqueous solutions of 10 ppm Acti-dione upon inhibition of Saccharomyces cerevisiae and phytotoxicity to Pinto or Bountiful bean.

Chlorophyll ppm	Inhibition of S. cerevisiae mm diameter	Phytotoxicity*
0	37	5
3.9	39	5
7.8	39	4
15.6	37	4
31.25	36	3
62.5	35	2
125.0	36	1
250.0	36	1
500.0	36	1
1,000.0	37	0

* Based on a qualitative scale of 0 to 5 (0 = no phytotoxicity).

[1]Acti-dione (cycloheximide), manufactured by the Upjohn Company, Kalamazoo, Michigan.

[2]Central Research Laboratories, United Fruit Company, Norwood, Massachusetts. Formerly Research Assistant, Department of Plant Pathology, University of California, Berkeley 4, California.

[3]Professor of Plant Pathology and Plant Pathologist in the Agricultural Experiment Station, University of California, Berkeley 4, California.

[4]Ford, Jared H., William Klomparens, and Charles L. Hamner. 1958. Cycloheximide (Acti-dione) and its agricultural uses. Plant Disease Reptr. 42: 680-695.

EXPERIMENTAL RESULTS

Crystalline Acti-dione at 10 ppm was added to aqueous solutions of chlorophyll at concentrations from 3.9 to 1000 ppm. The resultant solution was then bio-assayed for inhibition of Saccharomyces cerevisiae on a potato-dextrose-peptone agar surface by the filter-paper-disc method. The method was essentially that used by Whiffen[5]. These solutions were also sprayed onto Pinto and Bountiful bean plants which were in the primary leaf stage. After the spray droplets had dried the plants were inoculated with conidia of Erysiphe polygoni DC. All experiments were replicated and repeated. Results are presented in Table 1.

All treatments gave 100 percent protection against powdery mildew infections under conditions where the check plants were heavily infected. Injury was present only on plants which were sprayed with certain Acti-dione chlorophyll combinations. After 3 days from the time the bean leaves had been sprayed with the Acti-dione-chlorophyll solutions, the leaves were frozen; and the expressed juice was bio-assayed for inhibition of S. cerevisiae. The zone of inhibition in these tests varied from 30 to 36 mm in diameter. There was no apparent correlation between the chlorophyll content of the different solutions and the amount of inhibition due to the juice.

Treated leaves which had been washed under the tap for 3 minutes, and nontreated leaves did not give any apparent inhibition of S. cerevisiae. Unsprayed trifoliate leaves appearing after Acti-dione-chlorophyll treatment of the primary leaves of the same plant contained no inhibitory activity against this yeast.

When one primary leaf of a healthy bean plant was treated with these different concentrations of chlorophyll with Acti-dione, juice from the opposite primary leaf 5 days later gave no apparent inhibition of this yeast.

From these results it appeared that the chlorophyll effectively widened the margin between dosage levels of Acti-dione which gave control of powdery mildew of bean and those which gave undesirable phytotoxicity.

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EFFECT OF VARIOUS BACTERICIDAL SPRAYS ON CONTROL OF HALO BLIGHT DISEASE OF GARDEN BEANS[1]

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Abstract

During 1956 and 1957 spray tests were conducted for controlling bacterial halo blight disease (Pseudomonas phaseolicola (Burk.) Dows.) of garden beans. Topcrop beans free from halo blight were planted on new ground. Blight-infected beans were planted in rows adjacent to each plot to serve as an inoculum source. These spreader rows were also inoculated by atomizing with a water suspension of the halo blight organism. Bordeaux, Microgel, Tennam, captan, and Agri-mycin were applied as bactericidal sprays four times during the growing season of both years. In another treatment in 1956 bean seeds, before planting, were soaked overnight in 100 ppm of Agri-mycin. In 1956 infection was rather mild and the disease was effectively controlled by Agri-mycin 100 ppm, Microgel, captan, and Bordeaux. In 1957, when infection was severe, Bordeaux was outstanding in controlling halo blight. Beans sprayed with Bordeaux produced the highest percentage of marketable beans and the yield was more than twice as high as from any other treatment. In 1957 Agri-mycin was used only at 50 ppm and this concentration was not strong enough to control halo blight. It appears that Bordeaux and Agri-mycin 100 ppm gave the best control of halo blight disease of garden beans.

Garden beans (Phaseolus vulgaris) furnish a high quality vegetable for table use for many farm and city families in Montana. Garden beans are also raised in Montana on a limited scale for commercial seed production.

Growing conditions in Montana are generally good and excellent quality beans are produced. However, outbreaks of bacterial halo-blight disease of beans caused by Pseudomonas phaseolicola (Burk.) Dows. often ruin an excellent crop.

The results presented in this publication are a direct continuation of those published earlier (1, 2).

During the growing season of 1956 and 1957 tests were conducted at Bozeman, Montana. Topcrop bean seeds grown in Idaho and free from halo-blight disease were planted in new ground in four-row plots, 16 feet long. The rows were spaced 2 feet apart. Blight-infected seeds were planted in rows adjacent to each plot as an inoculum source. These spreader rows were also sprayed with a suspension of the pathogen twice during the 1956 and once during the 1957 growing season. In 1957, the plants were covered with polyethylene sheets after inoculation to simulate a moist chamber and thus assure good infection.

The following chemicals were applied to triplicated plots four times during the growing season: Bordeaux (71 grams per gallon), Microgel (18 grams per gallon), Tennam (6.8 grams per gallon), captan (18.2 grams per gallon) and Agri-mycin 100. In 1956 Agri-mycin was used in 50 ppm and 100 ppm concentrations. In another treatment, bean seeds before planting were soaked overnight in 100 ppm of Agri-mycin. Beans of the last treatment were not sprayed during the summer. In 1957 Agri-mycin was used only in 50 ppm concentration. All sprays were applied four times during the growing season. The spray applications started as soon as the beans began to develop the first trifoliate leaf and continued at approximately 2-week intervals until the middle of August. Sprays were applied at the rate of 0.735 gallons per plot (250 gallons per acre).

Regular readings of the occurrence of the disease were made in these plots. In 1956 very little blight developed before August 6 at which date a hail storm inflicted severe damage to the crop. Following this storm, there was a rapid outbreak of blight which continued to increase

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[1]Contribution from Montana State College, Agricultural Experiment Station, Bozeman, Montana. Paper No. 434, Journal Series.

until harvest. During 1957 infection of beans began to develop soon after inoculation and a severe outbreak of halo blight occurred about 2 weeks after inoculation. The blight continued to spread and increase rapidly until harvest.

At harvest time during both years all pods were harvested from the two central rows of each plot and divided on the basis of degree of infection into four classes: 1) healthy, 2) slight, 3) medium, and 4) severe. Pods with not more than two small, inconspicuous lesions were considered to have slight infections and these pods, together with the healthy pods, were classed as "marketable".

Tables 1 and 2 present the results obtained during 1956 and 1957 tests, respectively.

Table 1. Halo blight spray test - 1956.

Treatment	Healthy Pods	Infected Pods			Marketable Pods	Yield - Grams	
		Slight	Medium	Severe		Marketable	Total
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Pods	
1. Bordeaux	86	14	0	0	100	5138	5138
2. Microgel	66	30	4	0	96	6497	6768
3. Tennam	85	12	2	1	97	4181	4310
4. Captan	63	31	5	1	94	5354	5696
5. Agrimycin 50-55 ppm	72	25	3	0	97	5008	5163
6. Agrimycin 100-105 ppm	81	18	1	0	99	7187	7260
7. Agrimycin 100-105 ppm (Soak)	43	39	11	7	82	3798	4632
8. Check	54	31	11	4	85	3728	4386

Table 2. Halo blight spray test - 1957.

Treatment	Healthy Pods	Infected Pods			Marketable Pods	Yield - Grams	
		Slight	Medium	Severe		Marketable	Total
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Pods	
1. Bordeaux	72	22	4	2	94	4610	4904
2. Microgel	64	23	9	4	87	1724	1991
3. Tennam	57	34	8	1	91	1693	1860
4. Captan	42	45	10	3	87	1854	2131
5. Agrimycin 50-55 ppm	36	46	16	2	82	405	494
6. Check	44	34	19	3	78	540	692

The results of tests conducted in 1956 show that several of the bactericidal sprays were effective in reducing halo blight. In this test, infection was relatively mild even on the inoculated checks and under this condition Agri-mycin 100-105 ppm, Microgel, captan, and Bordeaux treatments resulted in the best yields. Bordeaux resulted in the highest percentage of marketable pods, but the yield was lower than with the other three compounds. There was some variation in the yield of replicated plots, which was probably due largely to a variation in the soil.

In 1957, Bordeaux spray was outstanding in controlling halo-blight disease. Severe infection was obtained on the inoculated beans and at harvest time many of the bean plots were almost completely defoliated because of blight. Under these test conditions, Bordeaux resulted in the highest percentage of marketable pods and the yield was more than twice as high as from any other treatment. Agri-mycin in concentration of 50 ppm apparently was not strong enough to control this disease. The yield of beans was inversely proportional to defoliation caused by the halo-blight organism.

In conclusion it may be said that Bordeaux and Agri-mycin 100 ppm gave the best results in controlling halo-blight disease of garden beans. Our results with Agri-mycin are similar to those obtained earlier by Zaumeyer et al. (3), using streptomycin.

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ON THE RESISTANCE OF CUCUMBER VARIETIES TO ANTHRACNOSE AND THE BEHAVIOR OF THE CAUSAL FUNGUS IN THE INVASION OF THE HOST TISSUES[1]

Shigeyasu Akai, Hiroshi Yasumori, and Haruka Terazawa

Summary

Inoculation experiments with Colletotrichum lagenarium on mature leaves, involving varieties and species of Cucurbitaceae, indicated that all plants were invaded by the pathogen. All squash varieties tested were highly resistant, whereas some varieties of cucumbers (Tsuda-Sanjaku, Sekino No. 2, and Wild cucumber) were resistant, others, such as Su-Yo and Kwashu-Zairai, were susceptible.

Varietal difference in susceptibility also was apparent from inoculation of cotyledons and mature leaves. Although the cotyledons of Shiro-Kikuza (squash) were affected slightly, the mature leaves of this variety were not infected. Lesions develop at approximately the same rate in all varieties of cucumbers. After the hyphae are established in the host, they develop equally well in resistant and susceptible varieties.

Sap extract of cotyledons of cucumber varieties accelerated the germination of conidia of C. lagenarium. The conidia germinated in the drops of water gathered from cotyledons of resistant and susceptible varieties that had previously been moistened with distilled water. Even when the cotyledons of squash were highly resistant to anthracnose, the conidia germinated and formed appressoria.

The percentage of infection hyphae that formed from the appressoria on cotyledons differed significantly among the cucumber varieties. Also, there was a high correlation between the percentage of infection hyphae formed and the number of spots per unit area of leaf. This presumably accounts for the difference in the susceptibility among varieties of cucumbers. The susceptibility also may be related to the character of epidermal cell wall.

INTRODUCTION

The anthracnose fungus, Colletotrichum lagenarium, attacks almost all varieties and species of Cucurbitaceae, often causing severe damage, especially to cucumbers (Cucumis sativus). According to Gardner (1), cucumbers are generally susceptible whereas squashes (Cucurbita moschata and C. maxima) are resistant. Recently, Kawai (3) called attention to varietal resistance of watermelon to anthracnose. Iwata (2) found that triploid cucumbers were more resistant than the diploid ones. In 1947 Iwata concluded that the tetraploid cucumbers, produced by the colchicine treatment, were more resistant than the ordinary diploid forms. He made no attempt to analyze the nature of resistance.

The present investigation was made during 1953 and 1954 in order to determine the nature of resistance in cucumbers to the anthracnose fungus.

MATERIALS AND METHODS

Colletotrichum lagenarium was isolated in August, 1951, by Yasumori from naturally infected leaves of cucumber. The conidia for inoculation and germination tests were obtained from the 8- to 11-day-old culture grown on a cornmeal agar slant at 24° C. Redistilled water was always used in making conidial suspensions.

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[1] Contribution from the Laboratory of Phytopathology, College of Agriculture, Kyoto University, No. 94.

We are indebted to Dr. Imamura, Professor of Applied Botany, Kyoto University, and Dr. J. J. Christensen, Professor of Plant Pathology and Botany, University of Minnesota, for kind suggestions and help.

Twenty-eight varieties[2] of cucumber and twenty varieties[2] of squash were used. Each was planted in a 12-cm pot and raised in the greenhouse. When the plants grew to about the five-leaf stage, side branches and tendrils were cut off and the conidial suspension was sprayed on the upper surface of leaves with an atomizer. The pots were transferred into a moist chamber at 24° C for 24 hours, then they were taken out and placed in the greenhouse. After 6 days, when definite spots developed, the total number of spots and the leaf area were measured.

EXPERIMENTAL RESULTS

All varieties of squashes tested were highly resistant to C. lagenarium, whereas some varieties of cucumbers were resistant and others susceptible. The varietal reaction of cucumbers to anthracnose is shown in Table 1. Although these data presented a wide difference in the number of spots per unit area of leaf among the varieties, it is virtually impossible to divide the varieties into two distinct groups, resistant and susceptible. Even resistant varieties developed a considerable number of lesions on their leaves. The data on the rate of enlargement per day of individual lesions are presented in Table 2. The spots were measured four or five times during a period from 7 to 14 days after inoculation. The enlargement of lesions occurred at about the same rate regardless of the varieties involved.

These results indicate that the difference in susceptibility (Table 2) of cucumber varieties is related to the number of spots produced per leaf, rather than to rapidity of lesion enlargement. Hence an experiment was designed to ascertain the nature of the mechanism that causes the difference in the number of spots on the varieties. In studying the nature of penetration, cotyledons of cucumber and squash were used.

Seedlings were produced at temperatures from 20° to 28° C in the greenhouse. Fifteen days after seeding, the cotyledons were cut off, and the lower surface was sprayed with a conidial suspension of the fungus and then put into a Petri dish on a sterilized moist filter paper. The dishes were kept at a constant temperature of 24° or 28° C. Symptoms of the disease appeared on the inoculated leaves after 4 to 5 days at 24° and 3 to 4 days at 28° (Table 3).

Cotyledons and leaves of cucumbers were equally susceptible to infection. Since cotyledons are more adaptable for experimental tests they were chiefly used hereafter in experimental work.

In previous tests it was apparent that differences in susceptibility among the varieties appeared to be at the primary stage of infections, particularly in the time of penetration. Therefore another test was made in which a heavy suspension of spores was used. On every cotyledon, ten drops of heavy or weak suspension of spores were placed and incubated in a moisture chamber at 28° C. One drop of weak suspension contained an average of a single conidium per field of microscope (x 150), whereas the heavy suspension contained about 89 conidia. In this test, spots that originated from a single drop were recorded as one lesion, even though many minute spots initially appeared. From this test it was apparent that all the varieties were severely attacked by C. lagenarium when they were inoculated with heavy conidial suspensions. Varieties inoculated with weak suspensions differed greatly in number of lesions that developed. The data are in accord with the results given in Table 3.

It seemed likely that the varietal difference in the susceptibility might be attributed to the amount of germination and initial infection, hence further tests were made in this area. The germination tests of conidia were made in water drops which were gathered from the surface of cotyledons. Redistilled water was dropped on the cotyledons and the cotyledons were kept in a moist chamber for about 6 hours at 28° C. Then the drops on the cotyledons were gathered and transferred to a glass slide also kept at 28°. The results indicated that the water drops gathered from the surface of cotyledons inhibited the germination of the conidia. However, there were no significant differences among the varieties (Table 4).

Studies also were made on germination of conidia in expressed sap of cotyledons and in a water drop containing a small piece of epidermis. Sap from each cotyledon was diluted three times with redistilled water. Almost all the conidia germinated and the germ tubes elongated vigorously without the formation of appressoria. Yoshioka and Naito (4) suggested that in watermelon the substances that inhibited the germination of conidia were located possibly in the cuticle and epidermal cells. A similar study was made with cucumbers. The lower epidermis

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[2] Seeds of cucumber and squash varieties were sent from the Kyushu, Osaka, Shizuoka, Shimane, and Hyogo Agricultural Experiment Stations, and the Aichi Horticultural Experiment Station. We wish to express our thanks.

Table 1. Reaction of cucumber varieties to Colletotrichum lagenarium as indicated by the number of lesions produced on the leaves.

Varieties	Number of spots per unit area (cm^2) of leaf		
	1st inoculation[a]	2nd inoculation[a]	Average
Tsuda-Sanjaku	0.19	0.39	0.29
Sekino No. 2	0.19	0.40	0.30
Taiwan-Kema	0.30	0.37	0.34
Wild cucumber	0.36	0.35	0.36
Sakata-Pickle	0.27	0.60	0.44
Ochiai	0.20	0.89	0.55
Shina-Sanjaku	0.32	0.79	0.56
Chiba-Ao-Hushinari No. 2	0.36	0.81	0.59
Ko-Jo	0.22	1.03	0.63
Kaga-Ao-Hushinari	0.58	0.75	0.67
Sekino No. 1	0.60	0.90	0.75
Seki-Jo	0.39	1.14	0.77
Kurume-Ochiai	0.52	1.02	0.77
Ochiai-Ao-Hushinari	0.38	1.23	0.81
Yamato	0.45	1.22	0.84
Sekino No. 3	0.70	1.07	0.89
Pekin	1.04	1.67	1.36
Jihai	0.56	2.29	1.43
Sagami-Hanpaku-Hushinari	1.15	1.87	1.51
Shiro-Hushinari No. 26-4	1.26	2.18	1.72
Dai-Hasshi	1.07	2.45	1.76
Shiro-Hushinari No. 32-5	1.59	2.37	1.98
San-To	1.95	2.36	2.29
Su-Yo	2.11	2.71	2.41
Nisshi-Aonaga	1.66	3.74	2.70
Kwashu-Zairai	2.89	4.40	3.65

[a] Three to four plants per variety with each plant having three to six, average five leaves were tested.

The first inoculation was made on September 1, 1953, and the second on September 2.

Table 2. The rate of enlargement of individual anthracnose lesions produced on leaves of cucumber.

Variety	Average enlargement rate of diameter of individual lesions (mm per day)
Wild cucumber[a]	1.1
Sekino No. 2[a]	1.8
Su-Yo[b]	1.2
Kwachu-Zairai[b]	2.0

[a] A small number of lesions was produced when inoculated.
[b] Abundant lesions were formed, see Table 1.

Table 3. Results[a] of inoculating cotyledons of cucumber and squash with C. lagenarium.

Variety	Number of cotyledons tested	Susceptibility, number of spots per unit area[b] of leaf
Cucumber		
Tsuda-Sanjaku	11	2.8
Kwachu-Zairai	11	4.5
Taiwan-Kema	8	5.5
Nisshi-Aonaga	11	5.8
Su-Yo	11	6.4
Squash		
Shiro-Kikuza	6	0.2

[a] With the exception of between Taiwan-Kema and Kwachu-Zairai, Nisshi-Aonaga, Su-Yo and between Nisshi-Aonaga and Su-Yo, significant at less than 5 percent level.
[b] Area of cotyledons was calculated as an ellipse.

Table 4. Percentage of germination of conidia in water drops gathered from the surface of the cotyledons of cucumber and squash respectively.

Variety	Number of conidia tested	Percentage germination	Percentage[a] germination of conidia with appressoria
Cucumber			
Tsuda-Sanjaku	1096	45.6	99.6
Su-Yo	1155	29.0	89.5
Squash			
Shiro-Kikuza	807	30.4	98.8
Redistilled water	1146	66.8	99.7

[a] Based upon the germinated spores.

Table 5. Relation between the incidence of the disease on cotyledons and the percentage of penetrating hypha formation from appressoria.

	Squash	Cucumber varieties				
	Shiro-Kikuza	Tsuda-Sanjaku	Kwachu-Zairai	Taiwan-Kema	Nisshi-Aonaga	Su-Yo
Percent[a] invasion	4.6	20.7	27.7	37.4	41.1	43.7
Relative value	11	47	63	85	94	100
Number of spots per unit area of leaf[b]	0.2	2.8	4.5	5.5	5.8	6.4
Relative value	3	45	70	86	90	100

[a] Average of five cotyledons.
[b] Average of six to eleven cotyledons.
$r = 0.996$, $P > 0.916$, significant at 1 percent level.

of cucumber cotyledons was stripped, and a small piece of this epidermis, about 4 to 6 square mm, was floated in a drop on a glass slide. Data on the percentages of germination were based on an incubation period of 14 hours at 28° C.

Germination was greatly accelerated when pieces of epidermis were added to water drops. This also greatly stimulated appressorial formation that gave rise to infection hyphae.

The penetrating hypha that emerged from an appressorium invaded the epidermal cells and developed further into the tissues. Development of hyphae in the epidermal tissues of cotyledons of cucumber varieties were followed in considerable detail. The epidermis of cotyledons was peeled off and 48 hours after the inoculation the hyphae were stained with anilin blue acetic acid solution. Then the number of epidermal cells that were penetrated by an infection hypha was determined. The results were based on 100 to 200 hyphae per cotyledon, involving one plant of each variety. There was no indication that varietal differences depended on number of cells that were invaded by the infection hypha.

The percentage of appressoria that gave rise to infection hyphae and that successfully invaded the epidermal cells was ascertained. In this test cotyledons from five plants per variety were used. Thirty hours after the inoculation the inoculated epidermis was peeled from the cotyledon and then stained with anilin blue acetic acid solution.

The number of appressoria from which the infection hyphae arose was comparatively few. During this period they had invaded only one epidermal cell. There was a positive correlation between the incidence of the disease and the percentage of invasion into epidermal cells (Table 5). Thus the severity of this disease among varieties is associated with the difference in the number of successful penetrations of infection hyphae. These results tended to indicate that the resistance of a cucumber variety to invasion might be due to the structure of the epidermal cell wall or to the defensive reaction of the epidermal cells, hence additional tests were made by wounding leaves.

The leaves were wounded by rubbing the leaf surface with fine particles of quartz sand. The wounding increased the relative number of spots both in resistant and susceptible varieties. Most of these openings were probably minute wounds in the epidermal cell wall, and it is clear that the variety Su-Yo is more susceptible than Taiwan-Kema.

DISCUSSION

The inoculation tests verified previous work, namely that marked difference in susceptibility to the anthracnose fungus exists among species of the Cucurbitaceae. All the squash varieties tested were highly resistant, whereas there were striking variations in susceptibility among varieties of cultivated cucumbers. The conidia of Colletotrichum lagenarium germi-

nated and developed vigorously in both the expressed sap of cotyledons and in water drops containing small pieces of epidermis from cotyledons of resistant and susceptible cucumber varieties. This indicates that the mechanism giving rise to the varietal difference in susceptibility is not related to germination and the production of appressoria. The successful penetration of the host was definitely associated with the variation in susceptibility. In fact a positive correlation of $\gamma = 0.996$ existed between number of spots per leaf and degree of susceptibility. Moreover, the wounding of the leaf surface greatly increases the percentages of spots in both resistant and susceptible varieties of cucumber, further suggesting that resistance and susceptibility are associated with the number of successful penetrations of infection hyphae.

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PATHOGENICITY OF TWO NEW RACES OF OAT STEM RUST[1]

G. J. Green[2]

Abstract

Two new races of stem rust were isolated from oats grown at Ste. Anne de la Pocatiere, Quebec, in 1957. These races are called 8A and 13A. The suffix "A" signifies that they can attack the varieties Rodney and Garry, which are resistant to races 8 and 13. Race 8A was avirulent to seedlings and adult plants of varieties with the White Russian type of stem rust resistance. Race 13A vigorously attacked all the varieties of Avena sativa L. inoculated with it except varieties with resistance from the variety Jostrain. Jostrain was not highly resistant to race 13A and tends to become more susceptible at high temperatures. The best seedling resistance to races 7, 7A, 8, 8A, 13 and 13A was found in A. strigosa Schreb. and some of its derivatives.

Late in 1957 two new races of stem rust, Puccinia graminis f. sp. avenae Erikss. & Henn., were isolated from oats grown at Ste. Anne de la Pocatiere, Quebec. Rust collected on the variety Rodney on October 7, 1957, caused resistant and susceptible type infections when inoculated onto seedlings of Rodney and Garry. An isolate from a single large pustule on Rodney, and a similar isolate from Garry, were identified as race 8. These two isolates attack both Rodney and Garry whereas no other culture of race 8 isolated at Winnipeg is virulent on these varieties. Stem rust collected on the variety Landhafer on October 25, 1957, also produced resistant and susceptible type infections on Rodney and Garry but an isolate from a large pustule on Garry was race 13. This isolate, like those of race 8, could attack both Rodney and Garry, whereas no other Winnipeg isolate of race 13 could do so. The two new races have been called 8A and 13A.

The origin of races 8A and 13A is obscure. The varieties from which the rust collections were obtained were grown in a uniform rust nursery sown at Ste. Anne de la Pocatiere for observational purposes. The sowing of this nursery was delayed so that the maximum amount of rust could develop on it before harvest late in October[3]. One or both of these races may have arisen through hybridization on barberry because barberry bushes are common in an area some 12 miles west of the nursery site and a single bush was found about 1/4 mile from the nursery. Alternatively, airborne urediospores of these races may have been carried into the area from the oat producing areas of New York or other north-eastern States by the prevailing south-westerly winds.

The seedling reactions of a selected group of stem rust resistant oat varieties[4] to races 7, 7A, 8, 8A, 13 and 13A appear in Table 1. Races 7 and 7A are included because 7A, like 8A and 13A, attacks Rodney, but unlike them it does not attack Garry. The varieties are readily separated into eight groups on the basis of their rust reactions. The reactions of the different groups can be explained by the presence of one or more of the well-known types of stem rust resistance found in the varieties White Russian, Richland, Jostrain and Rodney. Many of the varieties in Table 1 are resistant to races 7 and 7A. A number of varieties are resistant or moderately resistant to race 8 and moderately resistant to race 8A. Many varieties are resistant to race 13 but all the varieties are susceptible to race 13A except Sevnothree, Jostrain, and Roxton, which are mesothetic in reaction. In other tests, the results of which are not shown in Table 1, 33 additional varieties were susceptible to race 13A and 17 varieties introduced from Turkey were susceptible to races 7, 7A, 8, 8A, 13 and 13A.

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[1] Contribution No. 8 from the Canada Department of Agriculture Research Laboratory, Winnipeg, Manitoba.

[2] Plant Pathologist, Plant Pathology Section.

[3] Information with respect to the rust nursery at Ste. Anne de la Pocatiere was supplied by Dr. R. O. Lachance in a personal communication.

[4] Seed of the varieties used in the investigation was supplied by Dr. H. C. Murphy, Dr. F. K. S. Koo, Mr. J. N. Welsh, and Dr. F. J. Zillinsky.

Table 1. Seedling reaction of oat varieties to physiologic races of stem rust.

Variety	C. I. No.[a]	Reaction to physiologic race[b]					
		7	7A	8	8A	13	13A
White Russian		S	S	MR	MR	S	S
Minrus	2144	S	S	MR	MR	S	S
	6645	S	MS	MR	MR	MS	MS
	7243	S	MS	MR	MR	MS	MS
Richland	787	R	R	S	S	S	S
Sevnothree		S	S	S	S	X	X
Jostrain		S	X	S	S	X	X
Roxton		S	S	MS	S	S	X
Rodney	6661	R	S	R	S	R	S
Garry	6662	R	R	R	S	R	S
Minhafer	6913	R	R	R	S	R	S
	6936	R	R	R	S	R	S
	7151	R	R	R	S	R	S
	5962	R	R	R	S	R	S
	7235	R	R	R	S	R	S
	7148	R	R	R	S	R	S
	7236	R	R	R	S	R	S
	6878	R	R	R	S	R	S
	7095	R	R	R	S	R	S
	7144	R	R	MR	MR	S	S
Burnett	6537	R	S	R	MR	R	S
	7234	R	S	R	MR	R	S
	7020	R	S	R	MR	R	S
	7098	R	R	R	MR	R	S
	7145	R	R	R	MR	R	S

[a] C. I. refers to the Cereal Investigations accession number of the United States Department of Agriculture.

[b] S - susceptible; MS - moderately susceptible; X - mesothetic; MR - moderately resistant; R - resistant.

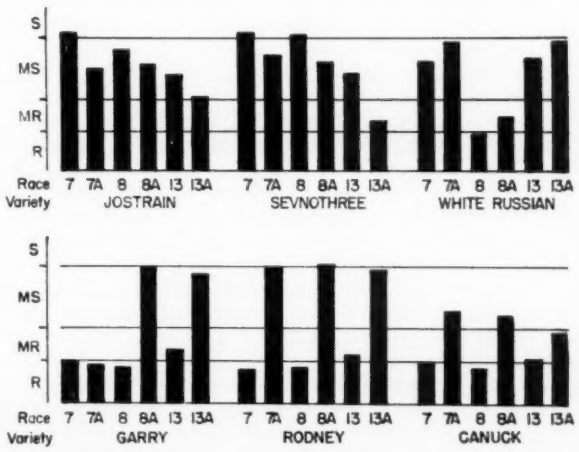
S
MS
MR
R
Race 7 7A 8 8A 13 13A 7 7A 8 8A 13 13A 7 7A 8 8A 13 13A
Variety JOSTRAIN SEVNOTHREE WHITE RUSSIAN
S
MS
MR
R
Race 7 7A 8 8A 13 13A 7 7A 8 8A 13 13A 7 7A 8 8A 13 13A
Variety GARRY RODNEY CANUCK

FIGURE 1. Adult plant reaction of oat varieties to races of oat stem rust in the greenhouse at relatively low temperatures. Symbols: R - resistant, MR - moderately resistant, MS - moderately susceptible, S - susceptible.

Table 2. Seedling reaction of oat varieties to physiologic races of stem rust.

Variety	Reaction to physiologic race					
	7	7A	8	8A	13	13A
Saia C.I. 7010	VR	VR	VR	VR	VR	VR
Avena abyssinica x A. strigosa C.I. 7232	MR	R	R	MR	MR	MR
A. abyssinica C.D. 4550[a]	R	R	R	MS	MR	MR
A. strigosa C.D. 3820	VR	VR	VR	VR	VR	VR
C.D. 3820 x C.D. 4550 SF6/56[b]	VR	VR	R	R	MR	MR
SF6/58	VR	VR	R	R	MR	R
68-13	R	R	R	R	R	R
68-31	R	R	R	MR	MR	MS?
68-5-1	MR	R	R	MR	MR	MR
68-5-2	R	R	R	MR	MR	MR

[a] C.D. refers to the Cereal Division accession number of the Canada Department of Agriculture.

[b] Selections from the cross C.D. 4550 x C.D. 3820 were supplied by Dr. F. J. Zillinsky, Cereal Division, Experimental Farms Service, Canada Department of Agriculture, Ottawa.

The adult plant reactions of the varieties Jostrain, Sevnothree, White Russian, Rodney, Garry, and Canuck to races 7, 7A, 8, 8A, 13 and 13A are shown in Figure 1. These reactions were evaluated by a method already described (3). Plants were grown in a greenhouse in which the maximum daily temperature rarely exceeded 75° to 80° F and the minimum nightly temperatures ranged from 45° to 55° F. Despite these relatively low temperatures, which would tend to retard rust development and increase the resistance of some varieties, Garry was susceptible to races 8A and 13A and Rodney was susceptible to races 7A, 8A and 13A. The varieties Jostrain, Sevnothree, and Canuck were moderately resistant to race 13A. The low greenhouse temperatures were probably partly responsible for this resistance.

Satisfactory sources of resistance to race 8A appear to be available. The variety White Russian, and many of its derivatives, are moderately resistant to races 8 and 8A in the seedling stage (Table 1). Adult plants of White Russian were resistant to race 8 and moderately resistant to race 8A in the greenhouse (Fig. 1). In the field the White Russian type of resistance is effective against race 8. There seems to be no reason why it should not be effective against race 8A as well.

It may be more difficult to obtain satisfactory resistance to race 13A. This race attacks seedlings of varieties with the White Russian, Richland, and Canadian types of resistance, and it induces a mesothetic reaction on the varieties Jostrain, Sevnothree, and Roxton (Table 1). It induced a moderately resistant reaction on adult plants of Jostrain, Sevnothree, and Canuck at relatively low temperatures in the greenhouse (Fig. 1). Jostrain, Sevnothree, Roxton, and Canuck appear to have the same type of resistance to race 13A. Jostrain and Sevnothree are known to be similar in stem rust reaction (1). Roxton has the same type of resistance as Jostrain (6) and Canuck has this type of resistance along with the Canadian type of resistance (5). Although Jostrain is not highly resistant and becomes more susceptible at high temperatures (2), there appears to be no other type of resistance to race 13A available in Avena sativa L. The moderate resistance of adult plants of Jostrain, Sevnothree, and Canuck in the greenhouse indicates that this type of resistance might provide a significant amount of protection from race 13A under field conditions in Western Canada.

The best seedling resistance to races 7, 7A, 8, 8A, 13 and 13A was found in the varieties Saia and C. D. 3820 of Avena strigosa Schreb. (Table 2). Selections from the progeny of crosses between A. strigosa and A. abyssinica Hochst. were moderately resistant. Lines SF6 and 68-13 are tetrapoid, and lines 68-31 and 68-5 are hexaploid. The transfer of this type of re-

sistance to A. sativa may not be especially difficult[5].

An increase in the prevalence of races 8A and especially 13A would create a new and dangerous situation in oat stem rust. The popular variety Rodney, which possesses the Canadian type of stem rust resistance, is susceptible only to races 7A, 8A and 13A. Race 7A has been known for several years but it is still a relatively uncommon race. The widely grown variety Garry is resistant to all North American races of stem rust except 8A and 13A. Garry, which possesses the Richland and the Canadian types of stem rust resistance (6), is widely used, especially in Canada, as a source of stem rust resistance. The combination of the Richland, Canadian, and White Russian types of stem rust resistance, as in the variety C.I. 7145 (4), is effective against all the races with which it has been inoculated except 13A. The unstable resistance of the variety Jostrain is the only well-known type of resistance in A. sativa that offers protection against race 13A. No commercial oat variety possesses the Jostrain type of resistance combined with other types of resistance that would protect against the races of oat stem rust common in North America. The threat of race 13A emphasizes the necessity for a continued intensive search for new sources of resistance in A. sativa and for the transfer to A. sativa of resistance genes from other species such as A. strigosa.

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5 Information with respect to the lines derived from C.D. 4550 X C.D. 3820 supplied by Dr. F. J. Zillinsky in a personal communication.

GREENHOUSE SCREENING OF CERTAIN FUNGICIDES FOR CONTROL OF RHIZOCTONIA DAMPING-OFF OF COTTON SEEDLINGS[1]

J. B. Sinclair[2]

Abstract

Some 42 fungicides and antibiotics, alone or in combination, were screened under greenhouse conditions to test their ability to control Rhizoctonia damping-off of cotton seedlings, incited by Rhizoctonia solani Kuehn. The greenhouse assays provided a method for screening chemicals and the assay results may be used to predict how those chemicals will perform in the field. Fungicides used alone that showed the most promise were PCNB, captan, nabam and dichlone. Combined treatments showing the most promise were PCNB plus dichlone; PCNB plus captan; nabam plus zinc sulfate; nabam plus zinc sulfate plus MN-3-9; and nabam plus zinc sulfate plus captan. When three chemicals were tested in combination, there was slight increase in control above two chemicals in combination. However, two chemicals in combination tended to give better control than did the same chemicals used alone.

INTRODUCTION

Cotton damping-off has been an important seedling disease of cotton since 1892 (1). It has been found in every cotton-growing area of Louisiana and is the one disease that, in recent years, has caused the largest estimated loss of cotton in the South (5). The organism most frequently isolated from diseased seedlings in Louisiana has been Rhizoctonia solani Kuehn. Recent reports from other States show that species of Pythium and Fusarium may be important pathogens in a damping-off complex (4, 7).

The screening of fungicides for control of cotton damping-off under field conditions is difficult because of the erratic occurrence of the disease from season to season in any one location (3). Screening of fungicides in the greenhouse, where more controlled conditions are available, might give basic information as to the effect of any single fungicide on one of the causal organisms, Rhizoctonia solani, and the extent of toxicity to cotton seedlings. This preliminary screening eliminates certain fungicides and only those showing the most promise would be tested in the field. This is the second report concerned with a program designed to screen various fungicides under greenhouse conditions, for control of Rhizoctonia damping-off of cotton seedlings. A report of earlier results has been published (9). This paper summarizes the results from trials conducted during the fall, winter and spring of 1957 and 1958 in which 42 fungicides and antibiotics were screened. These data will be used for selections of fungicides for further screening under field conditions in Louisiana.

The chemicals tested were:[3] PCNB; captan; nabam; Mylone (tetrahydro-3,5-dimethyl-2H--1,3,5-thiadiazine-2-thione); compound MN-3-9 (35 percent emulsifiable concentrated pelargonic acid); Omadine derivatives (2-pyridinethione 1-oxide, zinc and disulfide derivatives);

[1]The author is indebted to Dr. A. G. Plakidas, Plant Pathologist, for reading the manuscript, and to Dr. D. C. Neal, Senior Pathologist, U. S. Department of Agriculture, Agricultural Research Service, for helpful suggestions and advice.

Appreciation is expressed to the following chemical companies for providing samples of the fungicides and antibiotics indicated: Olin Mathieson Chemical Corporation (Omadine derivatives, PCNB and 2086); Stauffer Chemical Co. (captan and Vapam); Carbide and Carbon Chemical Co. (Mylone, D-121, D-113, B-1843, 1182 and Dyrene); Rohm and Haas Co. (nabam, zineb, and zinc sulfate); Mallinckrodt Chemical Corp. (MN-3-9 and MN-35); U. S. Rubber Co. (dichlone); Chas. Pfizer and Co. (Agri-mycin 100 and 500, anisomycin, Terramycin hydrochloride, streptomycin sulfate and nitrate); Monsanto Chemical Co. (20584, 16264, 15986, 16510, 20605, and 11611); Pennsalt Chemicals Corp. (TD-26 and TD-40); Upjohn Co. (cycloheximide derivatives); and Merck and Co. Inc. (potassium gibberellate and griseofulvin).

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[3]Chemical compositon is not listed here if it is given in references numbers 6 or 10 in Literature Cited, or when the composition is not known.

zinc sulfate; dichlone; Agri-mycin 100 (15 percent streptomycin plus 1.5 percent oxytetracycline); Agri-mycin 500 (A) (10 percent streptomycin plus 10 percent metallic copper plus 1 percent oxytetracycline); Agri-mycin 500 (B) (1.76 percent streptomycin plus 42.4 percent metallic copper plus 0.18 percent oxytetracycline); Terramycin (oxytetracycline and its hydrochloric acid derivative); streptomycin (sulfate and nitrate derivatives); anisomycin; griseofulvin; cycloheximide (acetate, semicarbazone, oxime derivatives, and compounds U-7510, U-7567, U-7594); Karathane; Vancide 51; 8-hydroxyquinoline sulfate; Dyrene (2,4-dichloro-6-(o-chloroanilino)-s-triazine); experimental fungicides TD-40, TD-26, 2086, 11611, 15986, 16264, 16510, 20584, 20605, D-113, D-121, B-1843, 1182; and potassium salt of gibberellic acid (0.88 percent potassium gibberellate).

The program was divided into two areas of study. In the first portion some of the fungicides that had looked promising from earlier studies (9) were tested in combination with one another. In the second portion experiments were run to test the effectiveness of other chemicals not previously studied and compared. This part included experimental chemicals and antibiotics (Table 1).

Table 1. Treatment means of seven replications for emergence (E), disease (D), and percentage of surviving healthy cotton seedlings from 50 seed (MH), when grown in sterilized field soil inoculated with an isolate of Rhizoctonia solani Kuehn under greenhouse conditions.

Treatment	Trial 1			Trial 2		
	E	D	MH	E	D	MH
PCNB	38.3	18.3	39	28.0	4.5	47
Captan	39.4	20.6	38			
Nabam	39.4	17.9	43			
Dichlone				30.5	5.5	50
MN-35				27.7	12.8	30
Terramycin HCl				26.3	11.3	30
Streptomycin sulfate				18.5	15.0	7
Streptomycin nitrate				20.7	12.7	16
Anisomycin				26.3	13.2	26
PCNB + mylone	31.5	20.6	23			
PCNB + dichlone				37.7	7.3	61
PCNB + captan				31.3	2.7	57
Nabam + mylone	30.3	23.1	14			
Nabam + captan	39.1	27.6	23			
Nabam + zinc sulfate				29.3	2.8	53
Dichlone + mylone				21.3	2.0	39
Omadine disulfide				26.2	7.2	38
PCNB + nabam + captan	40.0	25.3	29			
PCNB + nabam + zinc sulfate	39.3	24.1	30			
PCNB + nabam + mylone	33.9	23.1	21			
PCNB + captan + MN-3-9	37.6	23.4	28			
Nabam + captan + zinc omadine	33.4	31.3	4			
Nabam + captan + zinc sulfate	36.9	35.4	34			
Nabam + MN-3-9 + zinc sulfate	42.7	23.0	37			
Nontreated-inoculated check				25.8	25.8	0
Nontreated-noninoculated check	40.0	2.1	80	30.2	4.0	52
LSD.05	ns	2.6	6	1.5	2.0	16
LSD.01	ns	3.4	7	2.0	2.6	21

Greenhouse tests were run using sterilized field soil inoculated with the same isolate of Rhizoctonia solani used in previous screening (9). The organism was grown on potato-sucrose broth until a thick mycelial mat with sclerotia was produced, in about 7 to 14 days. The broth was decanted and the mat and sclerotia were mixed in a Waring Blendor with 200 cc of distilled water. This inoculum was mixed with the soil in greenhouse flats about 2 weeks before planting. Preliminary tests showed that the 2-week interval gave a more uniform disease index than did planting 1 week after inoculation. Single fungicides were applied at the time of sowing, at a rate of 5 pounds per acre for the wettable powders, and 4 quarts per acre for the liquids as in-the-furrow treatment. Combined fungicides were applied at equivalent rates. The following exceptions are noted: Agri-mycin 100 (100 ppm and 500 ppm), streptomycin nitrate (100 ppm), MN-35 (25 ppm and 100 ppm), anisomycin (100 ppm), Terramycin hydrochloride (100 ppm), cycloheximide derivatives (10 ppm), griseofulvin (10 ppm), Terramycin (500 ppm), Karathane (1000 ppm), Vancide 51 (1000 ppm), potassium gibberellate (50 ppm), and experimental fungicide 1182 (25 ppm). Inoculated-nontreated and noninoculated-nontreated flats served as controls. In most cases the materials were tested at least twice in separate runs. All treatments were replicated seven times, with 50 Deltapine-15 cotton seeds being sowed per replicate. Emergence counts and the number of seedlings showing damping-off symptoms were taken approximately 2 weeks after the sowing and treatment date. These figures were used to determine the percentage of healthy plants surviving from 50 seed sowed. Greenhouse temperatures were maintained as close as possible to 70° F (7).

GREENHOUSE RESULTS

Emergence data gave information on the control of pre-emergence damping-off as well as on the extent to which various chemicals were phytotoxic to germinating cotton seed. The disease reading, taken 2 weeks after treatment, gave information on the control of post-emergence damping-off. The percentage of surviving healthy plants gave a summary figure for easy comparison of different treatments (Table 1). The performance of the chemicals tested generally fell into three categories: 1) phytotoxic to the extent of inhibiting emergence completely; 2) moderately to slightly phytotoxic, thus reducing emergence and/or not significantly controlling damping-off; 3) slightly phytotoxic but giving promise of control of the disease.

Chemicals that fell into the first category were: TD-40, cycloheximide, cycloheximide acetate, Agri-mycin 500 (B), and Agri-mycin 100 (in a single run). Chemicals that fell into the second category were: all the cycloheximide derivatives not in the first category, cycloheximide plus iron sulfate, Agri-mycin 100 (in three runs), Agri-mycin 500 (A), Terramycin, streptomycin sulfate, Dyrene, griseofulvin, Karathane, Vancide 51, potassium gibberellate, Omadine derivatives, and the experimental chemicals TD-26, MN-35, 1182, 2086, 11611, 15986, 16264, 16510, 20584, 20605, B-1843, D-113, and D-121. Chemicals that fell into the third category were: PCNB, captan, nabam, dichlone, PCNB plus captan, PCNB plus dichlone, PCNB plus nabam, nabam plus zinc sulfate, nabam plus zinc sulfate plus captan, and nabam plus zinc sulfate plus MN-3-9.

Since none of the chemicals screened for the first time during the 1957-1958 tests approached the effectiveness of those materials showing the most promise from the previous screening, combining these data in tabular form did not seem to be warranted. However, a few of the antibiotics and experimental chemicals have been included in Table 1 for comparison with the more promising chemicals.

In the first trial the more promising chemicals from the previous screening were combined with one another to find out whether a mixture might improve disease control above that obtained from the same chemicals used alone (Table 1).

In the first trial there was no significant difference in emergence between the mean of the nontreated-noninoculated check and the means of all other treatments. Since there were no data available for a nontreated-inoculated check, the disease means and means for the percentage of healthy surviving plants were compared with the nabam treatment. In the latter category there was no significant difference between the means of nabam, PCNB, captan, and nabam plus MN-3-9 plus zinc sulfate. All other treatment means were significantly lower (.01 level) than nabam, with nabam plus captan plus zinc Omadine and nabam plus Mylone giving the least number of surviving healthy plants. All the treatment means for percentage of healthy plants are significantly below (.01 level) that of the nontreated-noninoculated check.

In the second trial, the more promising chemicals were compared with others that had not been tested before. In this run there was no significant difference between emergence means for dichlone, nabam plus zinc sulfate, and PCNB plus captan, but the emergence means for the

combination of PCNB plus dichlone was significantly higher (.01 level) when compared with the nontreated-noninoculated check. All other treatments except PCNB were significantly lower (.01 level). PCNB was significantly lower (.05 level). All the treatment means for disease were significantly lower (.01 level) when compared with the nontreated-inoculated check. The treatments showing the greatest percentage of surviving healthy seedlings were dichlone plus Mylone, PCNB plus captan, nabam plus zinc sulfate, PCNB plus dichlone, PCNB, dichlone, and Omadine disulfide, but these showed no significant difference from the nontreated-noninoculated check. All other treatments were significantly below (.05 level) the nontreated-noninoculated check.

In treatments in which Mylone was used in combination with either PCNB, nabam, dichlone, or PCNB plus nabam, Mylone was phytotoxic and disease control was not completely satisfactory. These results compared favorably with earlier ones (8). Mylone was tested further because it was thought that perhaps, if it was used in combination with other materials, and consequently at a lower concentration, its phytotoxicity also might be reduced enough to make its use worth while. This did not prove to be the case.

SUMMARY AND CONCLUSIONS

Significantly higher means at the .01 level over the inoculated-nontreated check indicate that these fungicides possessed some capacity for control of pre-emergence damping-off. Most of the treatment means for emergence, compared with the noninoculated-nontreated check, tended to be lower, indicating that pre-emergence damping-off was not completely controlled in these treatments or that the chemicals might be somewhat phytotoxic. Mylone and some of the antibiotics are examples of this type of reaction.

The ideal fungicide would give complete disease control. Therefore treatments resulting in the least amount of disease would be considered above treatments giving moderate control, even though some treatment means for disease were significantly lower (.01 level) than the nontreated-inoculated check. In evaluating any fungicide treatment in these greenhouse assays both emergence data and disease control must be considered, since a low stand count would give a low disease reading. The summary figure presented in Table 1 was based on the number of surviving healthy plants from 50 seed sowed and takes into consideration both pre- and post-emergence damping-off.

Comparing these latter treatment means, the single chemical treatments that appeared most promising were: PCNB, captan, nabam, and dichlone. Combination treatments showing the most promise were: PCNB plus dichlone; PCNB plus captan; nabam plus zinc sulfate; nabam plus zinc sulfate plus captan; and nabam plus MN-3-9 plus zinc sulfate. Where three chemicals were tested in combination there was slight increase in control above two chemicals in combination. However, two chemicals in combination tended to give more healthy plants than did the same chemicals used alone.

Neither the antibiotics nor the experimental fungicides tested gave any promise of increased control of this disease over the materials listed above. A combination of PCNB plus captan plus zineb (2, 8) gave a promising result in one out of three trials.

Results of these trials are being tested in the field, and additional greenhouse trials are in progress.

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LOUISIANA AGRICULTURAL EXPERIMENT STATION, BATON ROUGE, LOUISIANA

REACTION OF SAFFLOWER VARIETIES TO REGIONAL COLLECTIONS OF PUCCINIA CARTHAMI

C. A. Thomas

Rust, Puccinia carthami Cda., has been the most important disease of safflower, Carthamus tinctorius L., in the United States for the last several years. Most of the production of this oilseed crop has been on high water table land in the vicinity of Sacramento, California. Here, the disease usually has been prevalent and sometimes epiphytotic. Rust has been widely distributed in irrigated plantings in several other Western States. The general occurrence of this autoecious, brachyform rust probably is due to the ease with which seed-borne teliospores accomplish transmission (1, 2).

Table 1. Reaction[a] of safflower varieties and selections to races and collections of rust.

Variety or selection	Reaction to race or collection[b]					
	1	2	U	A	C	N
Nebraska 8	4	4	4	4	4	4
Nebraska 10	4	4	4	4	4	4
Nebraska 6	4	4	4	4	4	4
Pacific 1	1	3-4	4	4	4	4
Pacific 2	1	3-4	4	4	4	4
Western Oilseeds 14	1	3-4	4	4	4	4
Nebraska 977-16-1	1	3-4	4	4	4	4
Nebraska 977-15-1	1	1-2	3-4	3-4	3-4	1
Pacific 606-1-1-5-1	2	1-2	4	4	4	1
Nebraska 1-1-5	1	1	4	4	4	1
Pacific 780-3-3	1	3-4	1,4[c]	4	4	1
Arizona 6075	1	3-4	1,4[c]	4	4	1
Nebraska 977-19-1-1	1	3-4				

[a] 1, necrotic areas, a few of which contain small uredia; 2, most necrotic areas containing small to mid-sized uredia; 3, abundant, mid-sized uredia surrounded by chlorotic areas; 4, abundant, large uredia with no necrosis or chlorosis. Most distinct difference in reactions was presence or absence of necrosis.

[b] U, Logan, Utah; A, Mesa, Arizona; C, Woodland, California; N, Alliance, Nebraska. Reactions obtained with U collection were attributed to race 3, with A and C collections to races 2 and 3, and with N collection to race 4.

[c] 1, reaction on old leaves; 4, on young leaves.

The first rust-resistant variety of safflower (Western Oilseeds 14) developed for commercial production was susceptible to a new race that appeared in 1954 (3). Breeding for rust resistance since then has been complicated by the occurrence of apparently other races.

Uredospore collections were obtained in 1957 and 1958 from experimental plantings in California, Arizona, Utah, and Nebraska. The rust reactions of safflower varieties and selections to these collections of uredospores as well as to previously described races (3) were determined in the greenhouse[1]. Plants 6 weeks old were inoculated by dusting uredospores on moist leaves. Plants were placed in a moist chamber at 20°C for 16 hours and then grown in a greenhouse at a mean temperature of 22° for 1 month.

The rust reactions (Table 1) of certain selections and varieties indicated the presence of at least 4 races. The reactions obtained with uredospores from Utah were tentatively ascribed to race 3 and with those from Nebraska to race 4. Analysis of collections by inoculation of selected lines with single-pustule isolates may show the existence of other races.

Inoculation with uredospores collected at Woodland, California, in 1956 indicated the presence of race 3. The reactions obtained from spores collected there in 1957 and from Arizona in 1958 were apparently due to the presence of both race 2 and race 3. Evidence of this was obtained from the reaction of F_1 hybrids whose parents possessed resistance to the two races and from results of cross-inoculations with single-pustule isolates[2].

Inoculations with collections not given in the Table indicated the presence of races 2 and 4 at Davis, California, and of race 3 at Sidney, Nebraska.

It would appear that the present races will soon be found in all safflower-production areas since rust-infested seed is frequently exchanged between the areas. Combining resistance to all the present races appears possible and may result in successful control if other races do not appear.

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[1] Acknowledgment is made to Wade Parkey, Logan, Utah; W. F. Peterson, Scotts Bluff, Nebraska; D. S. Black, Mesa, Arizona; P. F. Knowles, Davis, California; and C. E. Claassen, Woodland, California for supplying uredospores and seed of safflower lines.

[2] Personal communication from K. E. Mueller, Department of Plant Pathology, University of California, Davis, California.

UNUSUAL RECORDS AND OTHER BRIEF NOTES ON PLANT DISEASE OCCURRENCE

A TECHNIQUE FOR MORE RAPID PRODUCTION OF PERITHECIA IN CERATOCYSTIS ULMI

By Martin A. Rosinski[1]

Recently there has been interest in obtaining perithecia of Ceratocystis ulmi (Buism.) Moreau as a means of determining the geographical distribution of the two compatibility strains[3]. Knowledge of the distribution of these two compatibility strains is important to persons attempting to develop varieties of elms which are resistant to the Dutch elm disease.

Holmes[3], using the method of Shafer and Liming[4] obtained perithecia in 1 to 3 months. Using the same culture method and the same "B" isolate[2] as was used by Holmes, but in combination with "A" isolates from Maine, perithecia were obtained by the present writer in a minimum of 9 weeks. Following the method described by Shafer and Liming but simply substituting distilled water for tap water, perithecia have consistently been obtained within 3 weeks.

Three different isolates of the "A" strain and one isolate of the "B" strain have been used in the present work. Comparison of the two culture methods was made, using all combinations of "A" and "B" isolates. The time required for production of perithecia was consistent only with the culture method used.

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[2]Cultures of the "B" strain were obtained from isolates made by Dr. Ralph Green, Department of Botany and Plant Pathology, Purdue University, Lafayette, Indiana.

[3]Holmes, F. W. 1958. Distribution of sexual-compatibility strains of Ceratocystis ulmi in Massachusetts. (Abst.) Phytopathology 48: 263.

[4]Shafer, Thelma, and O. N. Liming. 1950. Ceratostomella types in relation to development and identification of perithecia. Phytopathology 40: 1035-1042.

SUGAR MAPLE LEAF BLISTER IN NEW YORK

By Anna E. Jenkins

Sugar maple leaf blister, rarely recorded since the description of its pathogen (Taphrina sacchari Jenkins) in 1938[1], has been observed beginning with June this year on a roadside tree at Walton, New York. This is among roadside trees on which the disease was present in 1922 to 1931, as shown with an illustration in the article just cited. In 1939, Jenkins and Ray's[2] distribution map for Taphrina spp. on North American maples recorded 13 States for T. sacchari, ranging from Maine to Georgia and westward to Wisconsin, Missouri, and Arkansas.

MYCOLOGY AND PLANT DISEASE REPORTING SECTION, PLANT INDUSTRY STATION, BELTSVILLE, MARYLAND

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BROWN-SPOT OF CELERY IN CONNECTICUT

By Saul Rich

A field of celery near Hartford, Connecticut, was extensively damaged by brown-spot[1]. The infected stalks were covered on all surfaces with typical brown, scurfy spotting and streaking. This differs from the report of Segall[2] who found the lesions only on the inner surface of the stalks.

Mycelium was abundant in epidermal strippings from infected areas. Cephalosporium sp. was sporulating heavily on the surface and in the cracks of the lesions. This is presumably C. apii[3].

Infected stalks became much worse in storage and developed a soft rot.

The recent warm, moist weather has been particularly favorable for the development of the disease.

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN, CONNECTICUT

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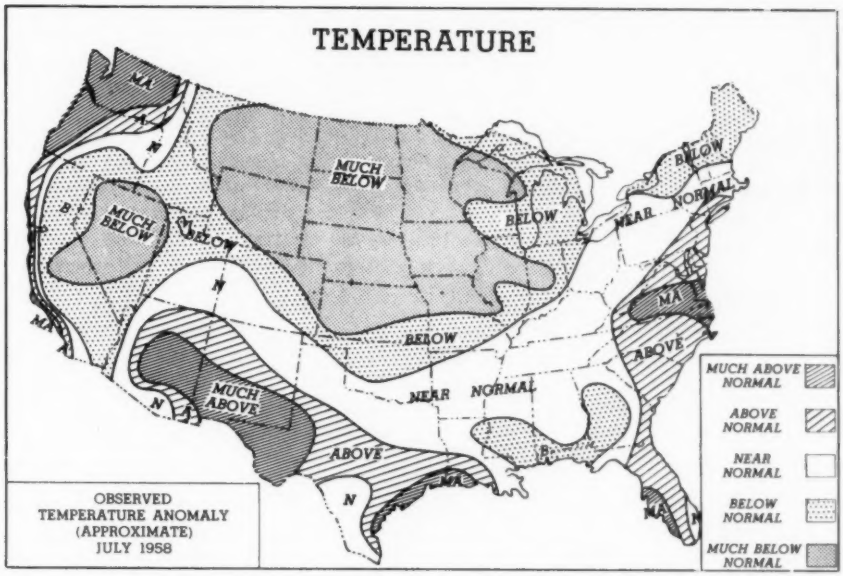

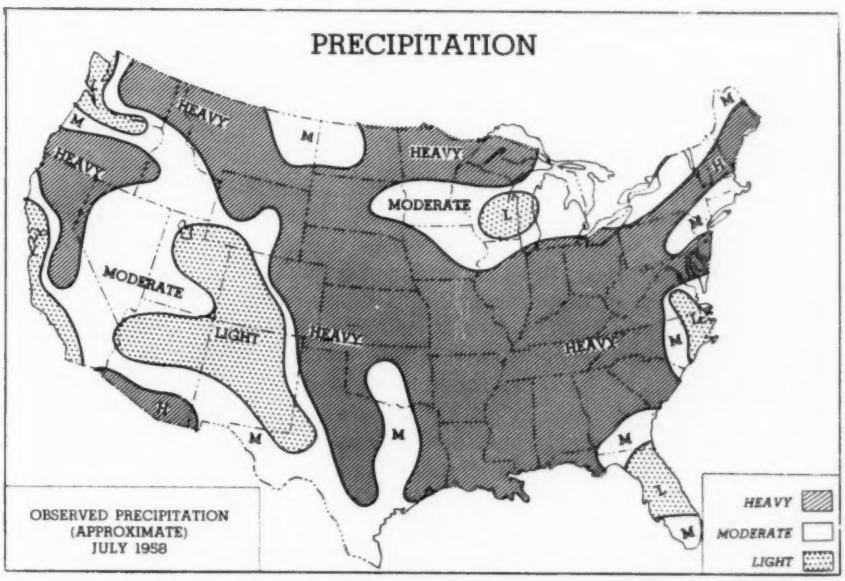

The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.